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Extracts from the Report of the Isthmian Canal Commission for the Year Ending June 30, 1911.

Construction and Engineering.

With a view of ascertaining the friction coefficient and leakage under working conditions, a series of tests of the rising stem or Stoney valves were undertaken at Gatun under the supervision of this division. From the first test, a coefficient of static friction at initial movement of 0.198 and rolling friction of 0.147 was obtained. The tests for determining this coefficient and leakage under working conditions are now being made. One of the cylindrical valves was tested for leakage at Pedro Miguel under a head of 65 ft. on the valve seat. The leakage under this head was found by measurement to be 0.128 cu. ft. per second, or about 1.3 cu. ft. per second for the 10 valves in each lock.

During the year, all the material under the contract for the fixed parts pertaining to the miter lock gates was delivered. The shops had completed on June, 1911, ready for shipment, practically all the material for the eight leaves 54 ft. 8 ins. in height, comprising the upper guard gates in Gatun and Pedro Miguel locks; eight leaves 77 ft. high for the upper and middle gates in the upper lock at Gatun were nearly completed, while eight more leaves 77 ft. high for the safety and lower gates in the same lock were about half done. Shipments from the shops aggregated about 7,000 tons. The output of the shops has reached about 900 tons per week, or nearly 1½ leaves.

Under the contract, the erection of the gates was to begin on Jan. 1, 1911, at Gatun, and on March 1, 1911, at Pedro Miguel. Although the contractor's erection plant was practically ready on the dates mentioned, actual erection was not begun until later due to delays in delivering the material. They commenced attaching the nickel steel bearing plates to the castings in the hollow quoins at Gatun on March 21, 1911, and placed the bottom girders for the four upper leaves in the upper guard gates on May 17 and 19. By the end of the fiscal year the skeletons of these four leaves were in position for a height of four panels and those on the east chamber completely riveted. No permanent work had been done at Pedro Miguel.

Fender chains are to be placed about 500 ft. above and 230 ft. below the upper and lower guard gates, respectively, in the locks at Gatun, Pedro Miguel, and Miraflores, and also at points 80 ft. and 100 ft., respectively, above the hollow quoins of the middle and safety gates in the Pedro Miguel lock, and in the upper chambers at Gatun and Miraflores. When not in use, these chains will rest in grooves in the floor and side walls of the locks. When in use, they will be raised to the surface of the water, forming a barrier to the passage of ships. The chain is arranged in such manner as to pay out against a resistance when struck by a vessel, and the strength of the chain and the intensity of the resistance are so calculated that the energy of a ship of 10,000 tons' displacement moving at the rate of about 4 miles an hour will be absorbed after striking the chain and before reaching the gate. During the year, the study of the device had made sufficient progress to determine the type of the first sample machine to be bought. The resistance will be provided by hydraulic cylinders at each end of the chain, the liquid from the cylinders being forced to circulate through a resistance valve, which will function only when a strain of about 100 gross tons comes upon the chain. Trial with the sample chain will determine the character of the remainder to be installed.

To permit examining, cleaning, painting, and repairing the lower guard gates, and for access in the dry to the sills of the emergency dams, it is proposed to provide floating caisson gates, and a design of the molded ship type has been prepared. An alternative design of the type now used for dry docks in the United States is under consideration; this may give less cost by eliminating largely the use of curved frames and plating. The caissons will be equipped with electric

GATUN LOWER LOCKS UNDER CONSTRUCTION JULY 27, 1911. MIDDLE AND UPPER LOCKS IN BACKGROUND.

motor-driven pumps for use in pumping out the caissons and for unwatering the locks.

The plans for the emergency or movable dams were completed in the early part of December, 1910, and work of constructing and erecting them in place was advertised Jan. 14, 1911. The contract was awarded to the United States Steel Products Co., the lowest bidder, for the sum of $2,238,988. The time pledged for completing the erection of the dams is as follows: At Gatun, Aug. 15, 1912; at Pedro Miguel, Jan. 15, 1913; and at Miraflores, June 15, 1913. The machinery for raising and lowering the wicket girders of the emergency dams and the gates which close the openings between these girders has been designed and is included in the above-mentioned contract.

Study has been given to the electrical system which will be used for the operation of the canal after completion. This contemplates a hydroelectric station on the Gatun Dam with a reserve generating station at Miraflores to be operated by steam. The two stations are to be connected by a transmission line, and current from either, or both, can be used for any of the operations of the canal. Specifications for the equipment of the hydroelectric plant are ready for issue.

The scheme for lighting the canal has been prepared and adopted. It contemplates the use of range lights for establishing the direction on the longer tangents, and of side lights spaced about a mile apart to mark each side of the channel. Three types of lighted beacons will be used and are to be built of reinforced concrete. The project contemplates the construction of 34 tower beacons, 57 beacons, 57 gas buoys, 76 spar buoys, and 7 nun buoys. Reference targets for marking the ranges where lights are not used and for fixing the location of the gas buoys will also be erected. The sailing lines marked by the range-lights, except at the entrances to the canal, will be so placed that all ships will follow a course 125 ft. to their starboard of the axis of the canal; thus two passing ships, if on their ranges, will have their center line 250 ft. apart. For locating and referencing the gas buoys, and for providing an unrestricted view of the range and reference targets, 1,000 acres of land must be cleared. Work was begun on April 20, and at the close of the fiscal year 375.5 acres had been cleared, 148,000 ft. of trochas cut, and 16,000 lin. ft. of profile taken.

In the report of the Isthmian Canal Commission for 1899-1901, Mr. S. H. Woodard discussed the effect upon the lock gates of the difference in densities between the water on the two sides of the gates of the lowest locks. In the course of the design of the lower portion of the lock flights at Gatun and Miraflores, it appeared that the pressures might prevent the opening of the gates, or even under possible conditions bring such pressure on the downstream side as would expose the operating apparatus to reverse stresses.

Further, the rise and fall of tide, especially at the lock leading to the Pacific, might occasion trouble at the lower gates if combined with carelessness on the part of the operating force. Thus, if the pair of lower operating gates and the pair of lower guard gates should be both shut, with the lower lock filled, on a rising tide the water outside the lower guard gates might rise, leaving the water in the space between the lower operating and guard gates at a lower level than either the water in the lock or the water outside, thus interposing difficulty in the operation of the guard gates; or, were the lower gates of the lock to be shut and the guard gates open, with the lock itself at its low level, on a rising tide reverse pressure would be produced on the operating mechanism of the lower gates.

These questions were considered by a board appointed for the purpose, and as the result of study and experiment the board reported that it is possible to find for a given condition of density, depth of water, and location of culvert, an elevation for the outlets of the culverts at which there will be no resultant unbalanced pressure on the gate leaves due to difference in density of water on the two sides after flow through the culvert has ceased. Applying the analysis to known conditions at the lower gates at Gatun and Miraflores, the board determined positions for the outlets of the culverts and recommended that they be placed at these elevations in the horizontal plane of the roof of the culvert, thus directing the flow of the water upward. It also recommended the placing of valves in the lower guard gates to provide against pressures due to tidal action. As a result, a design for the outlet of the culverts in the lower locks has been adopted, which it is believed with obviate any serious trouble.

Atlantic Division.

GATUN LOCKS.—During fiscal year excavation of lower lock was practically completed to include the location of the caisson sills. A total of 475,875 cu. yds. were removed by steam shovels, at a cost of $0.71 per cu. yd. The original estimated amount was increased by reason of slides in the lower lock, especially on the east side, and at the north end of the east side wall it was necessary to go to a depth of 66 ft. below sea level in order to secure a suitable foundation. The excavation to the north of the caisson sills will be done by dredges, and to prevent the water from flooding the lock while this excavation is in progress a concrete dam 50 ft. in height is projected, at an estimated cost of $30,000 for its construction and removal. In the preparation of the foundations for the locks there were removed by shovel, crane and hand 152,582 cu. yds., at a cost of $1.55 per cu. yd.

The construction plant was modified by changing the automatic railroad from the third-rail system to a trolley system, resulting in a more satisfactory service.

During the year the unloading cables were operated for 24 hours per day, except Sundays, and handled 500,550 cu. yds. of crushed stone and 241,858 cu. yds. of sand. Operating on the basis of 24 hours per day, 49.43% of the time was consumed in unloading operations; the balance lost in waiting for barges, 24.21%; and in other delays, 26.36%. These cableways averaged, therefore, 21.14 cu. yds. per hour while in service, or 42.77 cu. yds. per hour in actual working time of unloading. The operating cost of handling material by cableways and derricks, exclusive of plant charges, was $0.23 and $0.20 per cu. yd., respectively.

During the year 945,525 barrels of cement were received into the storehouse; in May, 1911, a change was made in the container, bags being substituted for barrels. During the year an average of 6.08 of the eight 2-yd. mixers installed in the construction plant furnished a total of 602,851 cu. yds. of concrete, bucket measurement, and were operated daily except Sundays on the basis of 12 hours per day, or at the rate of 26.56 cu. yds. per mixer per hour. The auxiliary plant mixers, two in number, operated on an average of 9 hours a day, except between September 21 and November 5, 1910, when they were operated on a 12-hour basis, and mixed 226,476 cu. yds., bucket measurement, or an average of 40.83 cu. yds. per hour per mixer.

The product of the construction plant mixers was placed by cableways or transferred by chutes to narrow-gage equipment, from which the concrete was dumped in place. The cableways were operated 12 hours per day; 64.16% of this time was consumed in handling 616,661 cu. yds. of concrete and large rock, 8.80% in handling forms and iron, and 27.04% in delays. Each cableway handled an average of 32.45 cu. yds. of rock and concrete per hour when engaged on that work. The narrow-gage equipment handled 286,265 cu. yds. of concrete and [illegible] stone. The total amount of masonry (co[illegible]te and large stone) laid by the construction [illegible]nt, auxiliary plant, portable mixers, and by [illegible] aggregated 911,137 cu. yds., or at a rate of 2[illegible] cu. yds. per hour in service. The cost of the masonry was $6.644 per cu. yd. The stone laid [illegible] the concrete was selected from material taken [illegible] Gatun from the Culebra Cut and was delivered on the banks at a cost of $1.34 per cu. yd. On the basis of the estimated amount of concrete required in the Gatun Locks, namely, 2,085,0[illegible] cu. yds., the masonry work at the close of the year was 68.34% completed.

Arrangements were made for the construction of concrete piles which are to form the foundations for the upper or south middle approach wall. A total of 31,060 ft. of piling was constructed of improvised reinforcement and 8,196 ft. driven. The cost amounted to $2.21 per lin. ft.. Sand for this work was obtained from the Pacific division. Owing to the difficulties experienced with the longer piles, the substitution of creosoted for concrete piling is under consideration.

EAST SECTION OF GATUN DAM, SHOWING DISCHARGE PIPE FROM DREDGE WITH HYDRAULIC FILL AT + 73, JULY, 1911.

GATUN DAM.—At the beginning of the year the north and south dry fills of the east portion of the dam, extending from the locks to the spillway, had reached an elevation of 65 ft. above mean tide, and the hydraulic or impervious portion between them had been carried to an elevation of 52 ft. At the close of the year the dry fills were raised to an elevation of 85 ft. and the hydraulic fill to +73. On July 1, 1910, the north and south dry fills of the portion on the west side of the spillway were at elevations 30 and 35 ft., respectively, and the intermediate hydraulic material was at +16; sufficient material was added during the year to make these elevations at the close of the year +60, +67, and +57.3, respectively. In securing this increase in the elevation of the earth portion of the dam the cross sections show that 2,060,186 cu. yds. of dry material were placed in the structure; also, that the dredges delivered into the interior portion of the dam some 3,758,870 cu. yds. of material. In other words, there was a total increase during the year of 5,819,056 cu. yds. by cross-section measurements.

Cross sections were made each month of those portions of the dam on which work was in progress with a view to securing the net yardage, but in comparison with the annual survey a shortage of 612,096 cu. yds. in the dry fill and 497,523 cu. yds. in the hydraulic fill is shown. In constructing the dam the dry fill is thrown toward the center, thus causing the material to rest on or sink into the hydraulic fill, depending upon the solidity and bearing power of the latter. This, together with consolidation that is in progress due not only to the natural settlement but also to the constant passage of heavy trains over the

mass, makes it impossible for purposes of cross sectioning to determine the line of demarcation between the dry fill and the wet. Also, by the method of construction, the hydraulic material is crowded toward the center as the dry fill progresses, thereby raising the liquid mass and creating a greater head at the drainage pipes, causing the escape of more of the wet fill than would otherwise result, in addition to which the hydraulic material is forced into the voids in the dry fill, making it impossible of accurate measurement, though at the same time making it a more compact and therefore tighter structure. A record of the amount of settlement in the dam was started, and for this purpose hubs were driven over the slopes of the dam about 250 ft. apart, parallel to and about 100 ft. apart at right angles to the axis. The elevations of these hubs are taken monthly and platted. Based on the monthly reports of materials placed in the dam, the cost for the year averaged $0.38 per cu. yd. for dry fill and $0.23 per cu. yd. for wet fill.

From Jan. 1 to April 15, pumping into the east portion was discontinued in order to determine to what extent the hydraulic fill would dry out and solidify. The tests showed a greater solidity the north side of the fill and when operations resumed more of the sandy material was ped along the opposite side. While a gradual idification took place during the dry season, e central portion showed but little change, and unless this soft material is crowded out during the subsequent construction, or hardened by addition of more sandy material, part of the fill must be drained off after the full height is reached.

Based on the estimated amount of material needed in the construction of the dam, it is 74% completed.

CHANNEL BETWEEN GATUN LOCKS AND ATLANTIC OCEAN.—To the north of the locks and between them and Mindi Hills one of the 20-in. suction dredges removed 423,427 cu. yds. from the canal prism, pumping the material into swamp areas to the east.

The dredges which operated between the Mindi Hills and deep water in the Caribbean in excavating the canal prism were the seagoing dredge "Caribbean"; the 5-yard dipper dredges "Chagres" and "Mindi"; and three French ladder dredges. These dredges removed 4,516,369 cu. yds. of earth and 487,038 cu. yds. of rock, at a cost of $0.22 per cu. yd., cost including plant charges and division expenses. The amount of silt deposited in the channel during the year was about 2,750,000 cu. yds.; in the first 2 miles of the channel surveys in June, 1910, and June, 1911, showed a silting of 310,901 cu. yds.; in mile 3 the silting was 902,038 cu. yds.; surveys made immediately after the norther of December 3 to 5, inclusive, showed a fill of about 370,000 cu. yds.

BREAKWATER.—Preparations were made so that active operations in the construction of the breakwater leading out from Toro Point could be undertaken at the beginning of the fiscal year. A trestle for the breakwater was started on August 9, 1910. At the end of the year 5,365 lin. ft. of double-track trestle had been completed, and 359,890 cu. yds. of fill dumped from the trestle. In addition, 619,152 cu. yds. of rock dredged from the canal were dumped in the vicinity of the breakwater. The average cost of the fill was $1.45 per cu. yd.

Central Division.

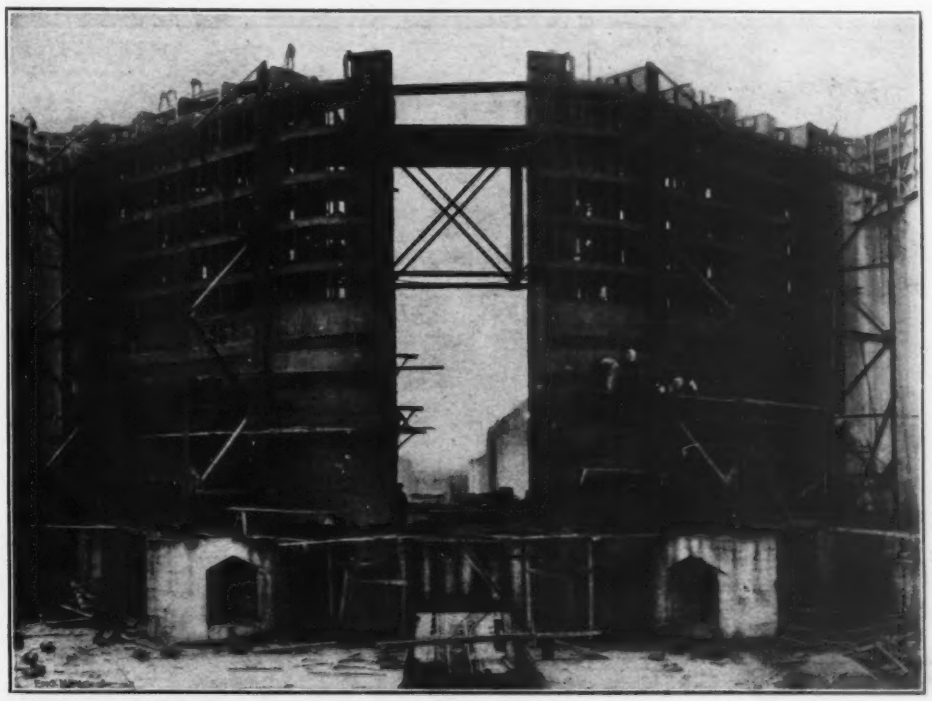
CHAGRES DISTRICT.—The total amount from the Chagres section during the year aggregated 2,301,020 cu. yds., leaving on July 1, 1911, to complete this portion 533,921 cu. yds. With the exception of the contracts still uncompleted, the balance of the excavation will be completed by suction dredges after the lake level is raised.

CULEBRA CUT.—During the fiscal year 16,221,672 cu. yds. were excavated, and from estimates prepared on July 1, 1911, there remained 23,929,140 cu. yds. to be removed in order to complete this section of the canal. It will be noted from the amount remaining that the estimate has again been increased over that reported a year ago by 4,676,278 cu. yds. This is necessary to allow for the slides which have developed beyond the limits assumed in the preparation of the former estimates. The total amount of material removed during the year outside of the slope lines and because of slides aggregated 4,879,378 cu. yds., or 30.07% of the total amount of material removed from the cut, as against 15% during the previous fiscal year. Thus far 10,757,658 cu. yds. of material due to slides have been removed, and the estimated amount remaining is 5,868,120 cu. yds.

Slides follow the excavation in places where the material is left at a steeper slope than it will assume in its natural state, in which case it sloughs off until the natural slope is reached and the movement ceases. The amount of material to be handled is relatively small and as a rule such slides are not troublesome.

In other parts of the cut layers of clay overlie smooth surfaces of rock or other material harder than clay sloping toward the axis. Excavating the material removes the pressure which previously existing held the clay in place. The overlying mass slides or slopes down into the lower area, the heavy rains assisting the movement. Thus far the only way of handling these slides is to remove the material as it enters the cut. In some cases all of it must be taken out, while in others only a portion, the amount depending upon the slope of the rock and the character of its surface. They are troublesome in that they interrupt the drainage and upturn tracks, thereby interfering with the progress of the work. Experience shows, however, that it is only a question of time when they will cease entirely.

In addition to the slides, breaks have occurred,



UPPER GUARD GATES IN EAST CHAMBER OF GATUN UPPER LOCKS IN PROCESS OF ERECTION, AUG. 5, 1911.

notably on both sides of the cut at Culebra. At localities where these have taken place the underlying rock is of poor quality, intersected by vertical seams or seams sloping toward the canal. As the excavation progresses, the distribution of the weight is changed, until by the concentration which follows, the breaking point of the weak stratum is reached and it is broken up and squeezed out of place, thus causing a heaving of the bottom or a pushing out of the side slopes, or both. A settlement of the overlying mass follows, accompanied by a movement toward the cut. Though the causes in the case of the slides and breaks differ, the effect is practically the same. The heaving of the bottom, or the pressing together of the sides of the shovel cut below, interferes with the drainage, covers or overturns the tracks, and interferes with the progress of the work.

The rational method of treatment in these cases seemed to be to relieve or reduce the pressure as much as possible, and work along these lines was directed in the latter part of the dry season on the west side of Culebra Cut, and has been so successful that a point has been reached so that the shovels at the bottom are not interfered with, and are enabled to move ahead without bulging due to pressure from this side. Intermediate benches along the slope are cut so as to distribute the top weight and reduce the amount of material that may have to be removed. Work was started similarly on the east side along the same lines. By carrying out this plan, when the bottom grade of the canal is reached it is apparent that no further trouble need be anticipated and that greater stability will be given by the water. It therefore appears that with both slides and breaks the question is one of ultimate amount of excavation, and, whatever the feeling elsewhere, there is no apprehension on the Isthmus as to the final outcome among those who are acquainted with the facts and who have given the matter any thought.

Thus far, also, the increases in the estimates of material to be removed made necessary by the slides will cause no increase in the total estimated cost for Culebra Cut, due to the reduction in the unit cost of the work effected by the increased efficiency of the organization; furthermore, there is no indication that such increases will delay the ultimate time of completing the work, because the progress has been greater than anticipated, and by working on the upper reaches of the slopes the output has been maintained.

Of the slides proper the one heretofore of greatest importance was that at Cucaracha, which covered 47.1 acres. Up to July 1, 1911, 2,722,164 cu. yds. of material had been removed, and there remain 400,000 cu. yds. The last shovel cut at the foot of Cucaracha slide was made in the first part of June, 1911, on the permanent berm at the 95-ft. level, since which time there has been no sign of any movement, the slide apparently being "dead."

The next largest slide heretofore noted was the Culebra slide, first reported as covering 7.3 acres. Since then, it has developed on both sides of the cut so that it now covers 46.6 acres, and at the present time is the most troublesome of all. On the east bank opposite Culebra it is estimated that 2,329,784 cu. yds. had been removed, and there remain 1,664,350 cu. yds. On the west bank, 3,714,562 cu. yds. have been removed and there remain 3,391,300 cu. yds. The other slides have diminished in importance.

As the depth of the cut has increased, egress therefrom for the dirt trains has become more and more limited, resulting in a decrease in the number of dumps that could be economically utilized. Trains were run from the south end of the cut at Pedro Miguel to the dumps at Balboa and Miraflores, and from the north end of the cut to the Gatun Dam, Tabernilla, and over the Gamboa Bridge to dumps on the Panama Railroad relocation, and 4,646,841 cu. yds. were dumped at Balboa in reclaiming land from the ocean and also in raising part of the area previously reclaimed. An additional 62 acres were reclaimed during the year, making a total area of 315 acres. The average haul to the dumps was 12 miles.

As previously reported, a breakwater was started from Balboa toward Naos Island with the object of cutting off silt-bearing currents from the excavated channel in the Pacific, thereby reducing the cost of maintenance and making navigation of the channel easier by eliminating the cross-currents. Prior to June 30, 1910, the trestle had been constructed for a distance of 2.4

miles. During the year just closed this trestle was extended 2,006 ft. so that the trestle was 2,737 ft. from Naos Island. The filling, however, extended to within 1,500 feet of the end of the trestle, or a distance of 4,237 ft. from the island. A great deal of trouble was experienced in extending the outer end of the dike, due to sliding of the bottom caused by the weight of the material dumped from the trestle. This sliding was encountered at every foot of the last 4,000 ft. of the dike and resulted in a settlement of the roadbed, which continued for the first two or three months, after which it gradually diminished and finally ceased. So far the work has been of material benefit to the channel.

The average cost for excavation for the year, including all items which enter into its accomplishment, was $0.59 per cu. yd. At the close of the year the Culebra Cut was 73.25% completed.

Pacific Division.

PEDRO MIGUEL.—The total amount of concrete laid during the fiscal year at Pedro Miguel was 498,187 cu. yds. at a cost of $4.71 per cu. yd. The total amount of concrete that had been laid steam shovels have excavated 247,700 cu. yds., at a cost of $0.74 per cu. yd., the material being used in the Miraflores Dam and back fill for the locks at Pedro Miguel.

CHANNEL BETWEEN LOCKS AND THE PACIFIC OCEAN.—During the last five months of the fiscal year, 197,880 cu. yds. of material were excavated in the dry by steam shovels between the Pedro Miguel and Miraflores Locks at a cost of $0.6888 per cu. yd.

In the area between Miraflores Locks and the Pacific Ocean, excavation was done by the hydraulic excavating plant and by dredges. After completing work in the lower lock chambers in February, 1911, the dredging units of the hydraulic plant were moved into the sea-level section of the canal, where they have since been operated. Numerous large boulders and sunken logs encountered in the process of sinking the barges on which the dredging pumps were installed, and the existence of rock requiring blasting at a higher level than the borings indicated, prevented the barges from settling to the grades desired, and in some instances injured the bottoms. For this reason the barges were abandoned and the

EAST CHAMBER OF PEDRO MIGUEL LOCKS, JULY 15, 1911.

in the Pedro Miguel Locks at the close of the year was 665,056 cu. yds., and, as the estimated amount remaining July 1, 1911, was 172,345 cu. yds., the lock was 79.42% completed on that date.

The concrete supplied by the construction plant was mixed on the berm cranes and transported by a narrow-gage railroad to the chamber cranes which placed it in the forms. There were two berm cranes in operation for 181 days and one berm crane for 93 days in addition; they worked on a basis of an 8-hr. day, averaging, however, 8.88 hrs. per day, and the four mixers connected with them produced at the rate of 70.30 cu. yds. per mixer per hour of actual working time, and 50.09 cu. yds. per mixer per hour of service time. The berm cranes while in service were engaged for 71.26% of the time in supplying concrete, the rest of the time was taken up in making repairs and waiting for cars. The chamber cranes laid a total of 401,725 cu. yds. of concrete and 1,430 cu. yds. of large rock during the year. They were operated on the basis of an 8-hour day, and they averaged 43.64 cu. yds. of material per hour service time, and 64.71 cu. yds. actual working time. The auxiliary mixers operated on the same day basis and produced 35.63 cu. yds. per mixer per hour working time, and 20.52 cu. yds. service time.

MIRAFLORES.—The hydraulic excavating plant began operations in the lower lock of Miraflores during the latter part of September, 1910, and continued until February, 1911, by which time practically all the overlying material had been removed; steam shovels were then resorted to for removing the rock. The hydraulic plant removed 332,703 cu. yds., at a cost of $0.5486 per cu. yd., the greater part of which was pumped into the Miraflores Dam. At the close of the year the dredging pumps placed at intervals along the axis of the channel with their suctions in sumps extending slightly below final grade. Two of the pumps were installed in this manner and the third was still operated from a barge. The amount removed from the channel by this process outside of the lock channel was 197,677 cu. yds., at a cost of $0.61 per cu. yd. in place. This cost is greater than anticipated, but since the dredging pumps can handle rock after it is blasted, which was not contemplated, the resulting cost is less than the combined cost of dredging equivalent amounts of earth and rock.

The dredges operating in the channel during the year were the 20-in. seagoing suction dredge "Culebra," one 5-yd. dipper dredge, and three French ladder dredges. The suction dredge operated over a length of 7.5 miles of the canal, measured from the sea end, and the others between the point reached by the "Culebra" and the area inclosed for operation of the hydraulic plant. They removed from the channel a total of 5,549,642 cu. yds. at a cost of $0.25 per cu. yd. At the close of the year there remained a total of 4,693,211 cu. yds. to be removed from the channel south of Miraflores, including an estimate for siltage.

Below a point 7 miles from the Pacific entrance to the canal the rock in the prism lies in separate shoals of small area and volume, which are removed by subaqueous methods. The rock breaker "Vulcan" was operated by two 10-hr. shifts until March, 1911, after which one shift only was used, as the shoal had been removed to a depth that made it impossible to work economically a greater length of time, due to the range of tides. The area covered by the rock breaker aggregated 648,033 sq. ft., and the amount of material removed after breaking was 49,26[illegible] cu. yds.

Terminals.

A board was appointed on [illegible] 24, 1911, to consider and report on the facilities that will be necessary in connection with the [illegible] of the completed canal, so that after the general scope and characteristics of these facilities have been adopted such work as may be needed may be undertaken. These facilities were to include the storing and furnishing of coal and other fuel for use both afloat and ashore; the furnishing of fresh water to shipping; the furnishing of adequate and convenient facilities for the repair of all vessels, as well as of all rolling stock, equipment, and machinery ashore; and the question of storehouses and storing of material and supplies on the Isthmus (other than fuel) for all other purposes after the completion of the canal.

A comprehensive scheme was outlined having in view the construction at the Pacific terminus of a dry dock, the permanent shops, and a storehouse for supplies. A coaling station is contemplated at each end and an arrangement of docks which will permit of subsequent additions. The dry dock is to conform in its dimensions to the locks, and the wharves are to be of sufficient dimensions to care for any shipping which can use the canal; in other words, the docks are to have lengths of 1,000 ft. and depths of water equal to the depths provided in the channels of approach.

On the Atlantic side it was decided that the docks should be within the limits of the Canal Zone, located so as not to interfere with traffic through the canal and at the same time to enable shipping to lie at them in safety during storms.

On the Pacific side a tentative location was selected for the dry dock and for the permanent shops, and an arrangement made for a scheme of docks. As the docking facilities of the Panama Railroad at Balboa are very much restricted, there was immediate necessity for additional wharves, and under an allotment from the Panama Railroad of $428,700 a reinforced concrete pier 706 ft. long and 55 ft. wide was begun.

In the construction of this pier a test pit was sunk and a line of borings was made along the outer edge of the proposed dock. Sand is encountered for about 20 ft., below which is a heavy bluish-gray clay upon a layer of gravel and sand overlying the rock. The latter is at depths varying from 60 to 70 ft. below mean sea level.

In the construction of the pier, caissons made of heavily reinforced concrete shells will be carried down to rock and ultimately filled with concrete. The bottom section of the caissons has an exterior diameter of 10 ft. at the base, tapering to 8 ft. at the top, from which the piers rise with the same thickness to the top; the interior diameter is 6 ft. throughout and the sections are cast 6 ft. in height. The caissons will be connected by tie-girders 3 ft. 6 in. deep by 2 ft. 6 in. wide extending transversely between the piers, and longitudinally between outside piers at an elevation of −10. The floor system will consist of girders running perpendicular to the axis of the docks, 4 ft. 8 in. deep by 2 ft. 6 in. wide. These girders will support a system of floor beams running longitudinally along the dock 3 ft. 9 in. deep by 1 ft. 3 in. wide, on top of which will be placed slabs 6 in. thick. Work was begun on the caisson construction during the last week in February, and on July 1 five caissons had been sunk to rock and 16 were in process of sinking; there are 55 caissons in all.

Construction of New Panama Railroad.

All grading on the line from Gatun to Gamboa was practically completed at the beginning of the fiscal year, except for about 3 miles where the line crosses the valleys of the Quebrancha, Brazo, Baja, and Gatun Rivers. The ground level of the Quebrancha bottom is at an average elevation of 20 ft. above sea level, while soundings indicate that rock is from 150 to 180 ft. below this elevation and that it is overlaid with a deposit of soft sandy clay, with a harder stratum of clay and pure sand near the surface of the ground.

As the height of the embankment across the bottom averages 71 ft. it was necessary to spread out the base of the fill so that if possible the weight would not disturb this upper stratum sufficiently to squeeze out the softer material below. With this in view the first fill was carried up to elevation 50 and out to 2:1 slope stakes. After this fill was made, a trestle to elevation 70 was driven across it, and filling from this level was started. A small settlement occurred along the trestle with a corresponding upheaval beyond the slope stakes and additional counterweight

was added on both sides well beyond the stakes, after which the raising of the center line to permanent grade was continued. On June 30, 653,505 cu. yds. of material had been placed in position.

Across the Brazo bottom the original elevation was about 30 ft. above mean tide, necessitating the construction of an embankment averaging 60 ft. in height. The filling across this bottom has given no trouble and 1,112,036 cu. yds. have been placed.

The Baja bottom has given trouble from the time that filling began. The elevation of the natural ground is about 25 ft. and the depth to rock is about 60 ft.; the overlying material, however, is the softest kind of clay intermixed with decomposed wood and vegetation. As the embankment settled additional weight was put along the toes and in this way the fill gradually raised until at the close of the year it was about 10 ft. below grade. The average fill over the valley is 67 ft., and at the close of the fiscal year 495,925 cu. yds. of material had been placed in the fill.

Under the original plans for the relocation of the Panama Railroad, the operating track was to be carried through Culebra Cut on the berm at elevation 95. Because of the slides which developed along the east side of Culebra Cut, and the necessity of maintaining through communication when the present line is flooded, the permanent location on the berm line through the Culebra Cut had to be abandoned, and a high line around Gold Hill was adopted and will be used until the condition of the banks through the Culebra Cut permit the return to the original location. The necessary surveys for the location of the high line were begun in July, 1910, and construction commenced January 1, 1911. This location necessitates a 1¼% grade and a maximum curvature of 7°. The cuts and fills about balance at 1,250,000 cubic yards. The length of the line is 9¾ miles from Gamboa to Paraiso.

The construction of the permanent telegraph and telephone line was undertaken during the year, and the poles used were made of 56-lb. steel rails.

In order to complete the excavation of the central division through the Chagres section at Tabernilla and San Pablo during the next dry season, it will be necessary to interrupt the operation of the old line, and to this end every effort is being made to complete the new line from Gatun to Gamboa by Jan. 1, 1912.

Mechanical Division.

Electric current for lighting and power was generated at five stations, located at Balboa, Miraflores, Empire, Gorgona, and Gatun. The output at the Gatun and Miraflores plants was largely used in construction work in the Atlantic and Pacific divisions, respectively. The cost per kilowatt hour averaged $0.026. Oil fuel was used in all stations. Current was generated at the Gatun and Miraflores plants by steam turbines, at the Empire and Gorgona plants by noncondensing engines, and at the Balboa plant by condensing engines.

The principal air-compressor plants are located at Las Cascadas, Empire, Rio Grande, and Balboa, and furnish compressed air to the central and Pacific divisions, and along the high line around Gold Hill on the relocation of the Panama Railroad. The total output from these plants aggregated 8,261,199,541 cu. ft., at a cost of 0.0324 ct. per thousand cubic feet. Compressed air for the Gorgona shops is furnished by a smaller plant located there.

Finances.

The total appropriations made by Congress available to June 30, 1911, amounted to $248,001,468, or 66% of the total estimate of $375,201,000 for completing the canal. By the act approved March 4, 1911, additional appropriations were made for the fiscal year 1912, amounting to $45,560,000, exclusive of fortifications, leaving $81,639,531 of the total estimated cost of the canal to be appropriated. By June 30, 1911, $225,470,053 had been charged into the work. Of this amount, $33,048,607.97 were expended during the fiscal year 1911. The difference between the appropriations available to June 30, 1911, and the classified expenditures to June 30, 1911, amounting to $22,531,415.32, represents unexpended balances in appropriations; unexpended material and supplies in storehouses; and such items as will not be prorated to construction work until the work is completed; buildings of all descriptions, roads, sewers, and water supplies. Of the total classified expenditures to June 30, 1911, $27,580,724.37 were for plant and equipment for construction, of which amount $626,330.86 were expended during the fiscal year 1911.

Cost Keeping.

The unit costs produced during the year are lower than at any previous period. The central division produced the lowest cost for excavation, and, as between the terminal divisions, that done in the Pedro Miguel Locks was lower by 11 cts. than in the Gatun Locks, but higher by 10 cts. than that done in the Gatun spillway. The excavation for the Miraflores Locks was the highest. In the preparation of foundations the Atlantic division did the work for less than the Pacific division. The high cost at Pedro Miguel is partly due to the layout of the work and partly due to changes in designs increasing the amount to be done at a time when the excavation could not be so economically handled.

In dredging, the Atlantic division secured lower costs with the seagoing suction and dipper dredges, and the Pacific division with the ladder dredges. In the latter division an underestimate of quantities to be handled resulted in the total plant charge being absorbed with the accounts for the month of April.

The total amount of masonry laid during the year was 1,741,908 cu. yds. in the locks and spillways. In the Pedro Miguel Locks the average division cost was $4.7040 per cu. yd., and in the Miraflores Locks $4.6826; in the Gatun Spillway, $6.7044, and in the Gatun Locks, $6.5919.

The difference between the costs in the Atlantic and Pacific divisions is mainly in the cost of cement, sand, and stone. The bulk of the cement used in the Atlantic division was received in barrels at a cost of $1.19 at tidewater in the United States, while the Pacific division received its cement in bags at a cost of $1.60 per bbl., less credits for return of bags. As approximately 90% of the bags were returned and accepted, the cement in bags cost $1.01 per bbl. at tidewater in the United States. The construction plant in the Pacific division also handles a large percentage of its cement directly from the cars to the mixer, thereby reducing cost, while nearly all the cement of the Atlantic division was handled through its storehouse.

While the year's operations show a difference in favor of Pedro Miguel Locks of $1.7340 in the cost of cement, stone, and sand, and large rock, the costs at this locality were also lower for forms, placing, pumping, power, repairs, plant arbitrary, and in division expenses, while a difference exists in favor of the Gatun Locks in mixing and reinforcement.

In the production of stone, the cost in the storage bins at Gatun was $2.3403, and in the storage piles for the locks on the Pacific side it was $0.8443 per cu. yd. Crushed stone from Porto Bello is transported to Gatun in barges and unloaded by cableways and derricks, while crushed rock from Ancon is transported from the quarry by rail to storage and dumped from trestles. There is, therefore, an extra expense attached to Porto Bello represented by the difference between the cost of towing and unloading and that of transporting by rail of $0.7184 per cu. yd. If this be deducted from the actual cost in storage, it leaves a cost of $1.6219 per cu. yd. for Porto Bello stone as against $0.8443 for Ancon stone for similar items in the cost of stone produced at the two places. This is in a measure explained by the harder quality of rock, by the method of quarrying and the layout of plant at Porto Bello. It is to be noted that the cost of production on an 8-hour day basis as compared with a 12-hour day basis is less for the former, both at Porto Bello and at Ancon.

Sand was produced at Nombre de Dios at a cost of $0.8795 per cu. yd. before transportation, or $1.8565 in storage at Gatun. The Pacific division secured sand at Chame at a cost of $0.1788 per cu. yd., and its cost in storage was $0.8284 per cu. yd. In both divisions the sand was transported by water to the point of unloading, the distance being 40 miles on the Atlantic side and 20 miles on the Pacific side. The Atlantic division used cableways and cranes to unload the sand, while the Pacific division used electric cranes. Omitting the cost of transportation from the sand bank to the docks, the cost to the Atlantic division was $1.3142 and to the Pacific division $0.6015.

Quartermaster's Department.

The average number of employees of the Panama Railroad and the commission was at its maximum for the year in January, 1911, when it amounted to 37,271. A minimum was reached in June, 1911, when it fell to 32,690. The average number of gold employees on the rolls of the commission during the year was 4,552; on the rolls of the Panama Railroad Co., 833, or a total of 5,385. During the same period there were 2,896 separations from the service of the commission—employed in the United States, 987, and employed on the Isthmus, 1,488—indicating that more than 60% of the force was changed during the year, the usual unstable condition of the gold force still ruling.

The past year has been the first since the inception of the work that no contract laborers were brought to the Isthmus. There has been a decided falling off in the immigation to the Zone. Quite a number of West Indian laborers have gone to the brush and can no longer be relied upon for steady work, so that the labor force has been depleted.

[The "Suggestions and Recommendations" at the end of the Report were printed in Engineering News of Oct. 26, p. 518.]

Plans for Completion of the Gatun Dam Spillway.*

During the period from the present to Jan. 1, 1912, work on the spillway of Gatun dam will be confined to the construction of the machinery tunnel to 69 ft. above sea level, the lower portion of the crest piers outside the channel of flow, the lower portion of abutments, flare walls, and approach walls. Work is now in progress on the forming for the machinery tunnel, 8 × 10 ft., which will extend the entire length of the concrete dam. A program for the construction of the spillway dam and works has been prepared as follows:

Period Jan. 1, 1912 to April 30, 1912.

Closure of channel of flow to elevation plus 50; and installation of sluice gates with operating machinery on piers at elevation plus 70. Estimated concrete, 25,710 cu. yds., an average of 257 cu. yds. per working day.

Every possible preparation will be made before Jan. 1 for doing this work at the maximum practical rate. Equipment for placing concrete, handling forms, etc., will consist of three derricks with 70-ft., boom so placed as to cover the full channel width; and movable chutes for depositing concrete at any point directly from dump cars. These facilities provide for placing concrete at over four times the required average rate.

During January and part of February, when the river flow is considerable, it is proposed to coffer off not more than two-thirds of the channel, completing the closure and opening the sluiceways not later than Feb. 28, when the discharge has dropped to about the minimum. Arc lights will be installed so that any night work necessary to advance the work may be advantageously prosecuted.

Period April 30, 1912 to Aug. 1, 1912.

Sluice gates to be closed at the beginning of this period and with normal flow, the lake will reach plus 50 at the end thereof. All concrete and bulkhead closures needed to force flood flow over central portion of dam at plus 50, as well as trash racks, pipes, control gates, etc., in hydroelectric plant forebay, will be placed during May. Thereafter, abutments and adjacent walls and crest piers will be carried toward final levels, working from a trestle at elevation plus 93. Estimated concrete, 8,800 cu. yds., an average of 117 cu. yds. per working day.

Period Aug. 1, 1912 to Jan. 1, 1913.

Concrete force will be employed principally in the construction of the hydroelectric plant. On the Spillway Dam about 2,500 cu. yds. will be placed, carrying crest piers outside channel of flow to final heights. This work to be done from trestle at plus 93 on top of ogee. If crest gates and foot bridges are ready, they will be placed during this period on the practically completed flanks of the dam. A study of maximum discharge for various periods indicates that the lake level will probably not exceed plus 59 under the conditions obtaining.

Period Subsequent to Jan. 1, 1913.

By manipulating sluiceway gates, the lake will be held at about plus 50, and the machinery tunnel, ogee to plus 69, and lower portion of crest piers will be completed across the channel of flow. Estimated concrete, 10,375 cu. yds. to be placed by April 1, average per day 138 cu. yds.

After April 1, the trestle at plus 93, already built along the top of the flanks of the dam, will be joined across the central portion; the remaining crest piers carried to final elevation (5,960 cu. yds.), the sluiceways filled (1,231 cu. yds.), and gates and machinery of same removed, about April 30; the crest gates and foot bridge placed by wrecking cranes working from the plus 93 trestle machinery installed in tunnel and the dam completed. With normal flow, the lake will gradually rise from plus 50 on April 30, to plus 69 on Aug. 1.

*From the "Canal Record," Oct. 18, 1911.

Progress on the Removal of the "Maine" Wreck in Havana Harbor.

We reproduce herewith two photographs, taken about the middle of October, illustrating the progress of the work upon the removal of the wreck of the "Maine" in Havana Harbor. The entire interior of the cofferdam has been laid dry, and work is steadily progressing on the cutting up of the wreck with acetylene torches into pieces small enough to be handled by derricks. About 150 ft. in length of the after portion of the hull has sustained comparatively little injury. It is planned to construct a temporary bulkhead across the front of this part of the hull so that it may be floated when water is let into the cofferdam. In order to enable this bulkhead to be built, a protection wall of steel sheet-piling has been driven across the hull, as shown in Fig. 1. The dirt and material back of this wall is being cleared away to permit the building of the bulkhead.

FIG. 1. THE WORK OF REMOVING THE WRECK OF THE "MAINE" IN HAVANA HARBOR.
(View near center of the wreck. A wall of steel sheet-piling has been driven as shown in the center of the picture. It is proposed to build a temporary bulkhead in the stern position of the hull behind this wall, in order that it may be floated.)

Fig. 2 is a view near the bow of the vessel and makes evident the extensive shattering of the hull by the explosion. This picture is an especially interesting study, as one recalls, the numerous schemes to raise the "Maine" which were brought forward by engineers and others a few years ago. Nearly all of these schemes were prepared with little or no knowledge as to the actual condition of the wreck; and many of the plans assumed that the hull was substantially intact, so that it could be lifted or handled as a whole. It was not generally appreciated that the "Maine's" hull was not merely a wreck but a wreck which had been blown to pieces by a terrific explosion.

FIG. 2. VIEW OF WRECK OF THE "MAINE" NEAR THE BOW, SHOWING THOROUGH SHATTERING OF THE HULL.

About 44% of the Pequannock Drainage Area of the water-works of Newark, N. J., was owned by the city at the close of 1910. The actual area so owned was 17,455 acres, or 27⅓ square miles. During 1910 about 120,000 trees, mostly white ash, spruce and pine, were planted in this drainage area. Mr. Morris R. Sherrerd, M. Am. Soc. C. E., is Chief Engineer of the Newark Street and Water Commissioners, and Mr. George Sansenbacher is Engineer of the Department of Water.

An English View of "Motion Study" as a Means of Increasing Labor Efficiency.*

The truth of the matter as to the value of motion study, as with many other matters, probably lies in a compromise between complete acceptance and complete rejection. It is likely, indeed it is certain, that a careful study of the motions made by an average workman in carrying out a job will show that by slightly modifying his practice the time taken to do the job might be cut down. And if the results of such study are used in a moderate way and as an aid to suggestion, and particularly as an aid towards improvement in the appliances the workman uses, they are likely to be of value.

*London "Engineering," Sept. 15.

We doubt their efficacy, however, if they are to be used as the foundations for a cast-iron code, which is to instruct the workman as to what he is to do in every detail. A man is not a machine, and no good can come from trying to make him one. Mr. Gilbreth himself says, "nearly every proficient workman loves his trade. He loves the joy of achievement."

We agree that largely this is so, but we do not agree that any workman, and more especially the better one, can love as well, or take the same interest in his work, when every possibility of personal initiative and individual treatment has been eliminated from it by a cut-and-dried accumulation of formulas.

The development of manufacturing processes is already rendering the worker's craft ever more and more mechanical. This is a development which appears to be inevitable in modern life, but in itself it has never appeared to have any virtue, and it is difficult to persuade oneself that good can come from going out of one's way to cramp the worker's personality, not only by means of the appliances he uses, but also by means of a rigid control of the motions of his body.

Mr. Gilbreth mentions military training as an example of what can be accomplished by means of motion study, and suggests that the care and attention given to training the motions of men for the art of war may well be bent towards training others in the arts of peace. But the available evidence all tends to show that the drill-master methods of the Army would have no advantages over present ways in the training of workpeople, and that the only result of adopting them would be a depreciation in the personal ability and initiative of the workman.

There is little enough room for the intrusion of personality in the manipulation of a capstan lathe as things are, and we do not and cannot believe that ultimate good can come from codifying every movement that is to be made in the operation of one, so that the man and machine together become a sort of automatic tool.

The Great Bridge Across the Lower Ganges, India.

Bridge construction across the large rivers of India is a problem far different than any presented to engineers in this country, both on account of the nature of the stream regimen and geology and the character of labor and equipment employed. The large rivers, such as the Ganges, run in their lower reaches through a low alluvial country in channels not at all definitely marked from one year to another and are subject during the rainy season to very sudden and terrific floods which raise the level far above the normal and subject any river structures to the most severe strain. To construct bridge piers of the proper stability in the insecure and shifting sands of the river bottom, to provide regulating works that will retain the river above and below the bridge in a fixed channel at all times and to do this with an enormous force of inefficient native laborers directed by a handful of white engineers helped out by a few European artisans, is the problem before the Indian bridge engineer. Any number of such structures have been built in the last 30 years, but none surpasses in total size that now under construction across the Ganges River, at Sara, about 150 miles above Calcutta on the railway between Calcutta and Darjeeling, in Northern Bengal. The July, 1911, issue of the "Indian and Eastern Engineer" contains a description of the work on that bridge, and from that article we have made the following abstract.

The Lower Ganges Bridge Project has been under consideration for a number of years, but has only just recently been actually put into execution. One season's work has already been completed and it is expected that four more will be required for completion. On account of the heavy rains and high stages of the river only a portion of each year can be devoted to the work. The location picked out for the bridge after a complete study of the general conditions in the neighborhood where economic considerations required the bridge to be built, is a right-angle crossing where the river is about 15,000 ft. between banks and 50 ft. maximum depth at flood and about 5,000 ft. wide and 18 ft. deep at mean low water. At the highest flood the volume of water passed is estimated to be 2,500,000 sec. ft. At this site it is proposed to build an approach embankment cutting off all but the channel, which is to be bridged by a 15-span steel truss bridge, resting on concrete piers sunk by the well-known Indian open-caisson method. Extending for over a mile upstream from each abutment there is to be built a massive Bell's bund, or guide banks, which is to keep the river in its proper channels. The plan of the two bunds at the bridge proper is shown in Fig. 1 and a section through one of them in Fig. 2. These two form solid banks between which the river must flow. They are formed of sand, faced with 9 ins. of stiff clay and pitched on the upper section first of all with 3 ins. of quarry chips or small stone and then with large pitching stone, to the dimensions shown in Fig. 2. The small stones below the heavy stones are to prevent the displacement or stirring up of the surface material of the bund by the lapping action of the water washing between the large stones.

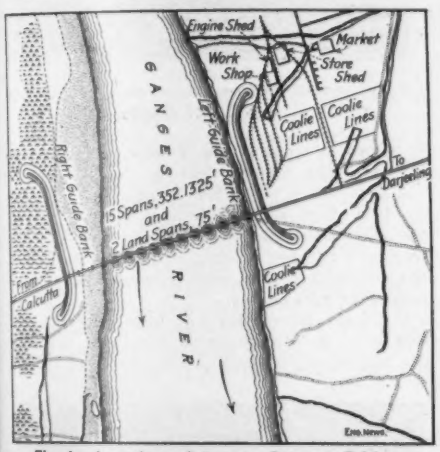


Fig. 1. Location of Lower Ganges Bridge.

The river side is covered with a layer of stone 3 ft. 6 in. to 2 ft. 6 in. thick and the back with a layer of stone up to the high flood level. In addition to these two bunds there are two more upstream from the bridge for the better regulation of the river there. In all these four bunds will require 1,000,000 cu. yds. of broken stone, distributed as follows: Right guide bank, 270,000 cu. yds.; left guide bank, 270,000 cu. yds.; Sara bund, 120,000 cu. yds., and Raitu bund, 210,000 cu. yds., and wave protection on the outer slopes, 30,000 cu. yds. In addition there is to be provided a reserve depot of stone for repairs, containing 100,000 cu. yds. The earthwork of the approaches will contain 570,000 cu. yds. besides the stone required for the bunds. While two bucket excavators are being employed in getting out the earth for the approach fills, by far the greater part of the filling is being done by coolie labor.

The piers, two of which are already in, are of the so-called "well," or open-caisson type, in which a steel cylinder is sunk into the sand bottom by dredging out the interior and afterwards filled with mass concrete to the top of the steel work and above that usually with brickwork. In this bridge, however, the showing portions of the piers are to be built of massive concrete block molded on the ground at the site.

Quoting from the above-noted article:

The foundations adopted for the piers of the bridge consist of wells 63 ft. over all in length and 37 ft. wide; the ends are semi-circular in plan connected with straight sides 26 ft. in length on the sides. The wells are provided with two open dredging holes 18 ft. 6 ins. in diameter concentric with the semi-circular ends. The steel work is made up of three parts. First the "curb" proper, the vertical drum plate of which is 15 ft. 7 ins. high from cutting edge to top of curb; the "cant" plates are carried up inside to the same height so as to form a completely plated structure. Above the curb and varying in number with the depth of water met with in each case are added what are termed "caisson strakes" consisting of iron plate sheets in continuation of the drum plate of the curb, as well as iron plate shell lining the dredger holes, these inner and outer shells being stoutly braced to withstand water pressure from the outside; these are designed in heights of 7 ft. each and, with the well curb, form a complete caisson that can be floated in water.

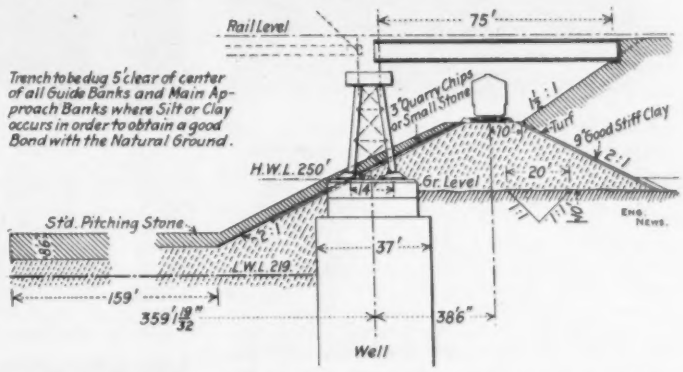


FIG. 2. SECTION THROUGH GUIDE BANK AT ABUTMENT OF LOWER GANGES BRIDGE.

Above the caisson strakes the steel lining of the dredger holes is carried up to the top of the well; these linings are termed "upper trunks" and are ordinarily in sections 9 ft. high, but, to suit variations in height required, the top section can be 4 ft. 6 ins. high only.

The whole of the curb and caisson strakes between the inner and outer plates are to be filled with mass cement concrete. Above the caisson strakes the outer 9 ft. of the well steining is designed to be built up with cement concrete blocks in courses 3 ft. thick, each block weighing about 7 tons, the central wall and the joint between blocks and upper trunks being filled with mass concrete laid in position.

The dredging holes will be filled with sand to within 18 ft. of the top, and thence a reinforced-concrete plug will close the dredging holes.

The wells are to be sunk by direct dredging. For this purpose, in situations where the curb is on dry land, 100 cu. ft. single wire rope Bell's dredgers will be used, working direct off the drum of an electrically-driven overhead traveling crane capable of exerting a tension on the lifting rope of 15 tons. In situations where the curbs have to be pitched in the river, the curb will be floated into position and then, a caisson strake being riveted on, the whole will be slowly sunk and further caisson strakes added till the curb is pitched. Here the dredging will be effected by means of electrically-driven vertical spindle centrifugal suction dredging pumps capable of delivering 1,400 gals. per min. The water being replaced in the well by means of an 8-in. siphon pipe drawing water from the river. Each suction dredger is provided with a 3-in. high pressure pipe capable of being connected to a pump that can throw a jet of water with a pressure of 100 lbs. per sq. in. at the nozzle against a head of 165 ft. of water; this provides for the contingency of meeting hard material during the progress of the sinking.

For the 16 wells contemplated the following quantities of material will be required to complete them:

125,000 cu. yds. of 1½-in. stone ballast.
75,000 cu. yds. of sand.
125,000 casks of Portland cement.
7,906 tons of steel work.

The design of the steel work of the bridge is still, it is understood, under consideration with the consulting engineers in London. The bridge will, however, consist of 15 spans of 352 ft. and two land spans of 75 ft., a total of 5,430 ft.; it will be noted from Fig. 2 that a minimum headway above high flood level of 40 ft. is provided for, as arranged after consultation with the steamer companies, and as low water level is 31 ft. less, during the period of low river there will then be as much as 71 ft. headway.

The bridge will provide for double line, and it is understood that the broad gage will be extended to Santahar, 52 miles from Sara.

On account of the primitive methods of earth carriage still generally in vogue in India an enormous force of men is kept at work. The census on March 10, of this year, for instance, showed the following count:

European officers	22
European and Eurasian subordinates	19
Indian subordinates (high class)	766
Indian subordinates (low class)	2,950
Indian contractors	162
European contractors	3
Contractors employees (European)	10
Contractors employees (Indian)	567
Coolies	12,627
	17,126

The arrangements for the accommodation of such a large force are naturally on a very bold scale. A large number of quarters, offices, engine sheds and shops have been constructed, and each bank of the river near the bridge site presents the appearance of a large town, with a full equipment of drainage and water-supply. In spite of all sanitary precautions, however, progress on the work last season was seriously interfered with by two cholera epidemics among the coolies. It seems that few great works of this character can be carried out in India without such outbreaks, owing to the fact that the common laborers decline to use the latrines provided, but persist in fouling the land instead.

For the construction of the bridge about 4,000 acres on both sides of the river have been acquired and about 741 acres additional for the three quarries required. Connecting up all this property some 81 miles of construction track have been built and are in use. In spite of the fact that so much of the labor is directly applied without mechanical aid, an elaborate power plant has been erected, comprising a steam-driven motor generating set which supplies electric power to all parts of the work.

The entire work is in charge of Mr. R. R. Gales, M. Inst. C. E., as Engineer-in-Chief.

Three German Electric Locomotives.*

In the present experimental operation of the Dessau-Bitterfeld line of the Prussian State Railways, in Germany, two express trains and nine ordinary passenger trains in each direction in addition to a large number of freight trains are electrically propelled. As all of these trains are for through traffic, only a locomotive service is possible. When, as expected, the electric service has been extended to the Magdeburg-Leipzig-Halle line, motor-cars may be employed. During a service of some five months, the locomotives furnished by the Allgemeine Elektricitäts Gesellschaft have proven thoroughly reliable. The steam locomotives, which now take the trains on to Magdeburg or Leipzig, are usually drawn over the track running light. The Dessau-Bitterfeld line employs a single-phase system.

The first locomotive, described as an express type and built for a speed of 68 mi. per hr., is shown in Fig. 1. It has the wheel arrangement 4-4-2, similar to the Atlantic type of steam locomotive. The leading axles are combined in a

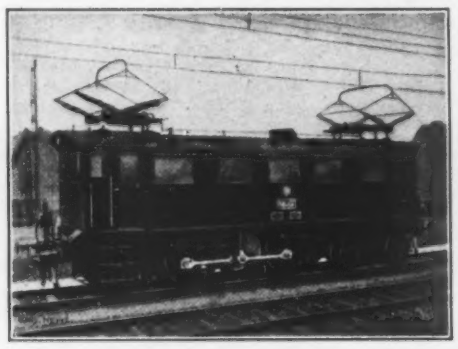


Fig. 1. Express Passenger Locomotive for the Dessau-Bitterfeld Line of the Prussian State Rys.

two-axle truck, while the trailing axle is called an "Adam" but not further described. The total length of the locomotive over the buffers is 41 ft. The fixed wheel base is 9 ft. 10 ins., and the guided length is 19 ft. 8 ins. The driving wheels are 63 ins. in diameter, so that they make some 400 r. p. m. at maximum speed. The two driving axles are connected by parallel rods to an intermediate crank-shaft pin, and from this by a vertical rod to the motor. The bearings for the intermediate crank shaft are in a horizontal plane between the two driving axles. On account of the vertical motor rod, a strong intermediate crank shaft is necessary, as the motor rod on one side is at a dead center when the parallel rods have to exert maximum effort. The entire traction load, therefore, is transmitted by the intermediate crank shaft from one side to the other at such positions. A cast-steel connecting piece is mounted between the motor and intermediate shafts to ensure permanent parallel positions. The bearing of the intermediate shaft is constructed in four parts, which may be adjusted vertically and horizontally by wedges. This bearing has a safety device in the form of a fusible plug connected with the main air tank, and operating the warning whistle in the driver's cab in case the bearing runs warm and the plug melts. The various driving rods correspond to usual steam locomotive construction.

The locomotive has one motor, shown in Fig. 2, given an hourly rating of 1,000-HP. The rotor is supported independently of the stator frame and has an axial play of about 1/10-in. The stator frame is fixed to strong cross girders of the locomotive frame and its position can be adjusted by wedges and pressure screws. The construction is entirely open as shown to allow convenient inspection of the commutator and brushes. The bearings for motor and intermediate shaft are oiled by a drip lubricator.

Current is taken at 10,000 volts from the overhead line by two pantograph collectors and is led through a choke coil to the main oil switch. It passes then to the high-tension winding of the main transformer through a current transformer and to the ground. The low-tension winding of the main transformer is provided with several taps so that the motor voltage may be varied. These different voltages are switched in by the contactors. The motor current flows from the low-tension winding to a reversing switch, which controls the direction of current in the field winding and thereby the direction of motor rotation. It then flows to the fields and the armature winding, through the compensating winding and back to the transformer. In addition, there is a "static balancer" or inductive resistance connected in parallel with the entire motor. This has a number of taps so that an intermediate lead, which goes to the connection between armature and compensating winding, may be shifted along the balancer windings. This allows of varying the proportions of the inductive resistance in parallel with the armature (plus the fields) and compensating windings, respectively. This enables the ratio of voltages between armature and compensating windings to be regulated according to the speed of the locomotive.

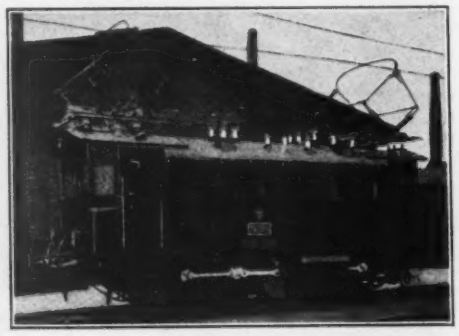


Fig. 4. Freight Locomotive for the Dessau-Bitterfeld Line.

Practically sparkless commutation is claimed to result.

The effort of the locomotive is regulated by a master controller (in a controller compartment) which operates the main contactors. The commutation connections are directly established by a second drum of the master controller. These two parts are worked separately by shafts and

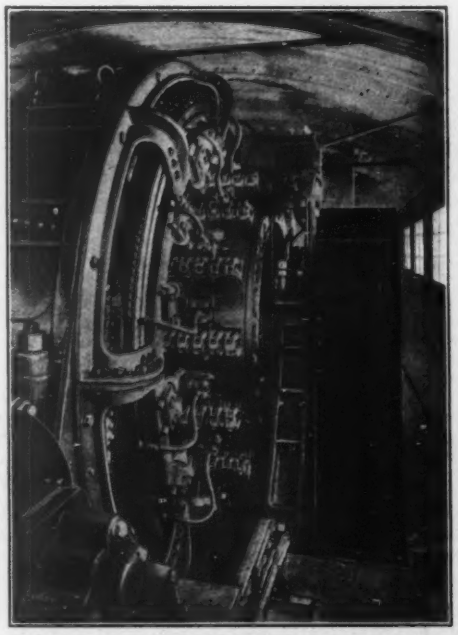


Fig. 2. Motor Compartment of Single-Phase Express Locomotive.

gears leading to a pedestal in the driver's cab (Fig. 3). The two hand wheels operating the two drums are placed one above the other. The different running speeds are marked on the lower hand wheel and the driver adjusts this according to his speedometer reading. The armature of the motor is short-circuited at starting by an air-operated switch on the master controller. There is a release device for the main oil switch operated by the brake, which prevents starting when the brake is on. Current for the control mechanism is supplied by an auxiliary coil on the main transformer.

This transformer is located in a compartment, adjoining one of the driver's cabs, provided above and below with ventilators. The main oil switch is mounted above it. In back of this compartment is the contactor and controller chamber noted. The main contacts are accessible from the side gangways of the locomotive.

Pantograph current collectors, built with ball-bearings, are used; bow-type collectors were originally used, but proved unsuitable at high speeds. The right-hand corner of the driver's cab is shown in Fig. 3. In the center foreground is the controller pedestal. Over the upper wheel is shown the speed indicator and above this the ammeter and voltmeter. At the right of the controller is the air-brake valve, and on the left the air sander and a switch for operating the air pump. The handle for the air warning whistle

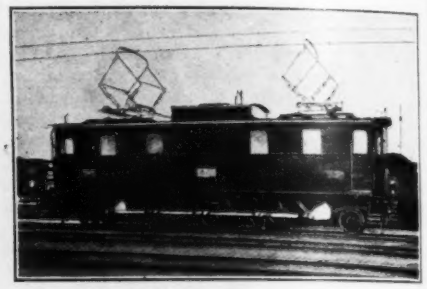


Fig. 5. General-Service Locomotive for the Southern Ry. of France.

is placed in front of the window, with two gages for the brake system close by.

According to tests, the locomotive developed a tractive effort of 9½ tons at starting. The average starting acceleration with a train of 280 tons was 0.19 mi. per hr. per sec. Since April, 1911, the locomotive has been employed for regular passenger service.

A freight locomotive has been constructed for this line, the design being somewhat similar to the passenger locomotive described, but differing

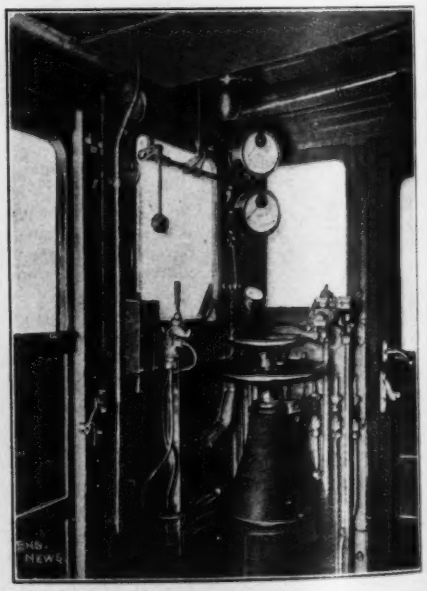


Fig. 3. Driver's Compartment of Express Locomotive.

from it in certain important details. This locomotive is designed to attain a maximum speed of 43.5 mi. per hr. As seen in Fig. 4, it has an 0-8-0 wheel arrangement with the entire weight of the locomotive on the drivers. The total length over buffers is 34 ft. 6 ins. and the total

*Arranged from articles by Mr. Werner Usbeck, in the "Allgemeine Elektricitäts Gesellschaft Journal" for August and September, 1911.

wheel base is 15 ft. 9 ins. To obtain flexibility on curves, one end axle has an axial movement of 0.6-in. on each side. The driving wheels are small (41.4 ins.) to allow a high speed of the motor. The maximum tractive effort is approximately 11 tons (at the driver periphery). The general equipment is much the same as the express passenger type already described.

The motor is not placed vertically over the intermediate crank-shaft, but in such a way that the motor rods are inclined at 45°. With this arrangement, a more favorable distribution of the stresses in the intermediate crank shaft is obtained by virtue of the fact that only part of the traction load has to be transmitted from one side to the other. A rigid connection is obtained between the motor-shaft and intermediate-shaft bearings by a steel casting bolted to the locomotive frame as in the express type. The bearings and other parts of the driving mechanism correspond to those of the express locomotive. The intermediate and coupling rods, however, lie in the same vertical plane, the intermediate rods being connected to the coupling rods by links. This gives a short crank pin. The motor has a maximum hourly rating of 800 HP. Its external construction and support on the locomotive frame are the same as in the express type.

The control differs somewhat from the method followed in the other type. The direction of rotation and the starting being effected by the shifting of the brushes. The axis of the brushes is shifted from the neutral position to one side or the other. Further control is effected by altering the motor voltage by means of a multi-tap transformer, the separate steps of which are switched in by a mechanically operated controller. To obtain good commutation at all speeds, a static balancer is employed much as in the other locomotive. The shifting of the brush rocker is done through a screw drive; the rocker is mounted on rollers and is connected, through a rod, with the nut of a driving screw. This latter is turned mechanically from a controller hand wheel in the driver's cab. The general arrangement of other apparatus and electrical equipment is similar to that of the express type. On account of the shunting which has to be done by a freight locomotive, a controller pedestal is placed on each side of the driver's cabins, which are at each end. This pedestal is similar to that of the express locomotive, having two hand wheels. The upper wheel is for regulating tractive effort and the lower one for speed.

The locomotive has taken up regular service and is employed for both passenger and freight trains. It has been found well adapted for passenger service, on account of its high starting torque, which gives a rapid acceleration of the trains and permits its holding to the schedule in spite of low maximum speed, compared with that of the express type.

The Allgemeine Elektricitäts-Gesselschaft has built a large freight locomotive for the Southern Railway of France, and this has been used on the Dessau-Bitterfeld line for several months. The Southern Ry. Co. of France intends to electrify a large part of its network north of the Pyrenees and this locomotive has been ordered for an experimental service on the line Villefranche-Marquisanex. Fig. 5 gives a general view. The total length over buffers is 43 ft. 2 ins.; the total wheel base is 31 ft. 5 ins. and the fixed wheel base 11 ft. 10 ins. The diameter of the drivers is 51.6 ins., and the diameter of the leading wheels is 33.5 ins. The crank circle has a diameter of 21.3 ins. The center axle is given a side play of 0.79-in. on each side to ensure flexibility on curves. The two running axles are held in radial trucks, each having 2.2 ins. side play to either side, and provided with strong return springs to guide the locomotive around curves. The total service weight of the locomotive is about 85 tons, of which 54 are on the drivers. As shown in Fig. 5, there are two motors, driving the axles through two intermediate crank shafts, which are placed between the running axle and the first pair of drivers. The motor rods are inclined at an angle of 45°. The intermediate and first coupling rods lie in the same vertical plane with the former connected to the latter by links. This gives short crank pins with advantageous distribution of stresses. On account of the side travel of the center axle, the coupling pin of this axle has the same allowance for side play. The motors are mounted high on the frame as near the center of the locomotive as possible. The main transformer is placed in the center of the locomotive between the two motors.

The electrical equipment is designed for an overhead line potential of 12,000 volts and a frequency of 16⅔ cycles. Each motor has an hourly rating of 800-HP., which gives a maximum tractive effort of 13.7 tons at the drawbar. The maximum speed is 46.5 mi. per hr. and control of the motor is by variable voltage. The working current (secondary) passes from the various taps of a transformer through the contactors to the stationary winding of the motor and through an exciting transformer. The latter supplies current for the fields of the motor, which are developed in the rotor windings. This exciting transformer is a single-coil type with a variable transformation ratio, the regulation of field voltage being through solenoid contactors which connect to proper taps. As a rule, the motor runs with the main winding of the rotor short-circuited. But as the locomotive has to increase its normal speed of about 25 mi. per hr. up to 46.5, the rotor circuit is opened at the higher speeds for feeding in auxiliary current to it. This is done with a part of secondary winding of the main-transformer. The proper voltage is taken from taps through solenoid-operated contactors.

Some of the contactors are mounted in a frame over the main transformer, the remainder being in special cases at the ends of the motor compartment, where are located the exciter transformers, motor compressor and reversing controller. The upper part of the locomotive is completely enclosed, and the roof carries two collectors similar to those on the other two locomotives described. They may be raised and lowered by a compressed-air valve in the driver's cab. Sections of the roof over the motors and transformer may be removed to permit lifting the apparatus out with a crane.

This locomotive has drawn freight trains weighing 1,500 tons at a speed of 25 mi. per hr. on a 4% gradient. It has also proved suitable for passenger service on account of its heavy tractive effort at starting, giving a rapid acceleration of trains.

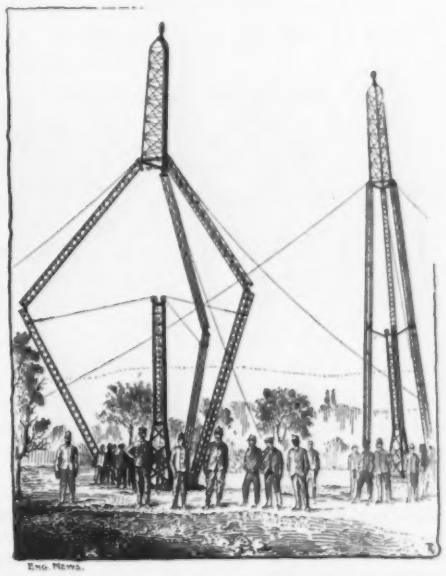
At the order of the French railway company, provision has been made for the return of current to the line on down grades. This has a value on the steep gradients of the Southern Railway of France, but complicates the switch gear. The controller handle has a position for the regenerative braking, in addition to that of forward and backward travel of the locomotive.

Trials were made on the Dessau-Bitterfeld line with the regenerative-braking control; these had to be carried out by allowing the locomotive to be dragged along by another, owing to the absence of proper gradients. It was reported that, at medium speeds, the regenerative braking was very satisfactory.

A Comprehensive Sewage Purification Scheme for the Sanitary District of Chicago, looking well into the future, has been reported by a special commission, including Mr. Geo. M. Wisner, M. Am. Soc. C. E., Chief Engineer of the District; Mr. Edward B. Ellicott, M. Am. Soc. M. E., Electrical Engineer of the District; Dr. W. A. Evans, until recently Health Commissioner of Chicago; Mr. C. D. Hill, M. Am. Soc. C. E., Superintendent Chicago Bureau of Sewers, and Mr. Martin C. Schwab. The commission recommends the construction of some twenty groups of Imhoff tanks, these to be completed by 1922, and be followed years hence by sprinkling filters, beginning in 1930, all at an estimated cost of $12,658,000. The commission was appointed by Mr. R. R. McCormick, while President of the District, but the continuance of its work was objected to by Mr. McCormick's successor, President Smythe, according to reports. It is also stated that the new president is opposed to the printing of the report of the special commission.

A Demountable and Portable Gin-Pole.

An erecting derrick or gin-pole which can be rapidly and easily erected and which can be taken apart for transportation has been devised by Messrs. Bosco and Donatelli for the Italian army, to be used primarily in the erection of air-ship sheds. The sheds, intended for the large dirigibles, are made up of a series of parabolic arch trusses, tied together by longitudinal struts or purlins and covered with a heavy metallized cloth or canvas. Each arch is a three-hinged truss about 100 ft. wide and 80 ft. high. They are each divided into a number of pieces of a size small enough to be packed upon wagons or railway cars and arranged for bolting together into two main members, one on each side of the crown pin. In practice, they are taken to the desired location, bolted together into the two halves and, each bottom hinge resting on a special shoe, the two halves are raised by the portable derrick and joined together at the crown hinge. The next arch is then erected and the structure successively completed by joining the adjacent arches by the purlins and finally covering with the canvas. Such



Portable and Demountable Gin-Poles Used in Erecting Air Ship Sheds for the Italian Army.

a shed some 230 ft. long was recently erected complete in six days and proved very stable under the strongest winds.

The gin-pole used in the erection is also of a demountable and portable type, which can be transported along with the shed members. A view of two of the poles is shown in the accompanying cut. The one on the left is being raised into place and that on the right is complete, ready for work. As shown there, the gin-pole consists of three sloping stiff-legs carrying above them a rigid framework for the working sheaves. Each of the stiff-legs is hinged to bend outward at its middle, and pinned securely to a solid frame at the bottom. To this frame there is attached a short vertical member carrying at its top three pulleys, in line, respectively, with the three stiff-legs.

When the pole is to be erected, the lower vertical post is first placed on the frame and the upper framework is placed over it, and attached to the tops of the stiff-legs which are lying, jack-knife fashion, on the ground, and fastened at their lower pins to the solid frame of the pole. Lines are then carried through the pulleys on the lower post to the stiff-legs and power applied so as to lift the stiff-legs into their final position. When they are straight, the hinged joints at their middles are fixed and the stiff-legs braced and tied to the center frame, as shown on the pole to the right in the view. During the operation the pole is kept from toppling by guy wires attached to the top of the stiff-legs.

The device is described and illustrated in "Le Genie Civil," for Sept. 9, 1911.

A Diagram for Determining the Area That Can be Irrigated Under a Given Combination of Lifts by a Given Power.

By E. A. MORITZ,* Assoc. M. Am. Soc. C. E.

The use of water power generated by falls in canals has come to be common on irrigation projects, and irrigation engineers are often called upon to determine the feasibility of such propositions; that is, to determine the area that can be covered, the probable cost, etc. A proper investigation of such a problem involves the determination of the relative economy of using one or more lifts. For use in this connection the diagram described below has been devised and has proved to be a great time saver. The writer has taken an example from his own practice, in order to outline the procedure.

THE PROBLEM.—Given an area of land, as in Fig. 1, higher than the canal *a b c d*, on which topography has been taken with a 10-ft. contour interval. At *D* a drop of 46.03. ft. occurs into a lateral, the quantity of water dropping being 140 cu. ft. per sec. Determine the area that can be irrigated from this power.

GOVERNING CONDITIONS AND ASSUMPTIONS.—The quantity of water required to be pumped is 1 cu. ft. per sec. to 144 acres continuous flow, or 1 cu. ft. per sec. to 72 acres one-half time, or 1 cu. ft. per sec. to 48 acres one-third time. Assume turbines and direct-connected centrifugal pumps to be used having a combined efficiency of 52.5%. The velocity, entry and friction heads through gates and penstock are estimated to amount to 1.20 ft. leaving 44.83 net drop (46.03 — 1.20) available for power. Assume further, in order to eliminate the friction loss in delivery pipe from consideration in connection with the lifts, that 5% of the gross power is lost in friction of water in the delivery pipe. We then have a net power available in water pumped of

$$\frac{44.83 \times 140}{8.8} \times (0.525 \times 0.95) = 356 \text{ HP.}$$

PREPARATION OF DIAGRAM.—From the topographic sheet determine the area that can be covered under various lifts by assuming certain rates of fall for the laterals. Plot these data and draw the curve (Fig. 1) marked "Irrigable area under given lift," referring to scales (1) and (3). In this case the curve happens to be practically a straight line. Plot the curve marked "Cu. ft. per sec. that can be raised to given height with 356 HP.," referring to scales (1) and (2). The equation of this curve is:

$$\text{Lift} = \frac{8.8 \times 356}{Q},$$

where Q is the cu. ft. per sec. pumped.

Plot the curve marked "Acres that can be irrigated with given cu. ft. per sec. at 1 cu. ft. per sec. to 144 acres," and the corresponding curves for 1 cu. ft. per sec. to 72 acres and 1 cu. ft. per sec. to 48 acres, referring to scales (2) and (4). The manner of determining points on these curves is obvious.

Finally, plot the curve marked "Acres that can be irrigated under given lift with 356 HP. at 1 cu. ft. per sec. to 144 acres," and the corresponding curves for 1 cu. ft. per sec. to 72 acres and 1 cu. ft. per sec. to 48 acres, referring to scales (1) and (3). Since

$$\text{Lift} = \frac{8.8 \times 356}{Q} \text{ and } Q = \frac{A}{144}$$

we have

$$\text{Lift} = \frac{8.8 \times 356 \times 144}{A}$$

as the equation of the first of these curves, and

$$\text{Lift} = \frac{8.8 \times 356 \times 72}{A}, \text{ and}$$

$$\text{Lift} = \frac{8.8 \times 356 \times 48}{A},$$

respectively, for the other two. The diagram is now complete and ready for use.

Use of Diagram.

SINGLE LIFT.—With water flowing continuously, duty is 1 cu. ft. per sec. to 144 acres. At the intersection of the "irrigable area" curve with curve A we read on scale (3) that 4,300 acres can be covered at a lift of 105 ft. Curve A tells us that 4,300 acres can be supplied with the required quantity of water at this lift with the power available. The single lift problem is thus solved.

TWO LIFTS.—With water flowing to each lift one-half time, the duty is 1 cu. ft. per sec. to 72 acres.

(First Lift.) At intersection of curve B with "irrigable area" curve we read on scale (3) that 2,850 acres can be reached and supplied with water at a lift of 80 ft.

(Second Lift.) Assume 110 ft. for the high lift. The total area under this lift from the irrigable-area curve is 4,600 acres. The area to be watered from the high lift is therefore 4,600 — 2,850 = 1,750 acres. We next determine if sufficient water can be pumped with the power available to supply this area. From intersection of the "power curve" with 110-ft. line, drop a perpendicular to the duty curve at E. Follow horizontally from this point to scale (4) and read 2,050 acres as the area that can be watered at this lift with the available power. We must therefore lift higher and get more area. Assume 115 ft. lift. A total of 4,900 acres are reached by this lift, making 4,900 — 2,850 = 2,050 acres to be watered from the high lift. Drop a perpendicular as before, from the 115-ft. line on the power curve to the duty curve at F and read on scale (4) that 1,960 acres can be supplied with the power available. Therefore 115 ft. is slightly too high and by another trial we find that 113 ft. gives the desired adjustment, with a total area of 4,850, of which 2,850 acres are under the low lift and 2,000 acres under the high lift.

THREE LIFTS.—With water flowing to each lift one-third time, the duty is 1 cu. ft. per sec. to 48 acres.

(First Lift.) At the intersection of curve C with the irrigable-area curve, we read on scale (3) that 2,200 acres can be reached and supplied with water at a lift of 69 ft.

(Second Lift.) Assume 100 ft. for the second lift. From the irrigable-area curve, the total area under this lift is 4,000 acres, making 4,000 — 2,200 = 1,800 acres to be watered from the second lift. Drop a perpendicular from the 100-ft. line on the power curve to the duty curve at G and read on scale (4) that 1,500 acres can be supplied. The lift is therefore too high. Trying 96 ft., the total area is 3,770 acres, making 3,770 — 2,200 = 1,570 acres to be watered by second lift. Dropping down to the duty curve we read on scale (4) that 1,570 acres can be supplied. This is the adjustment desired.

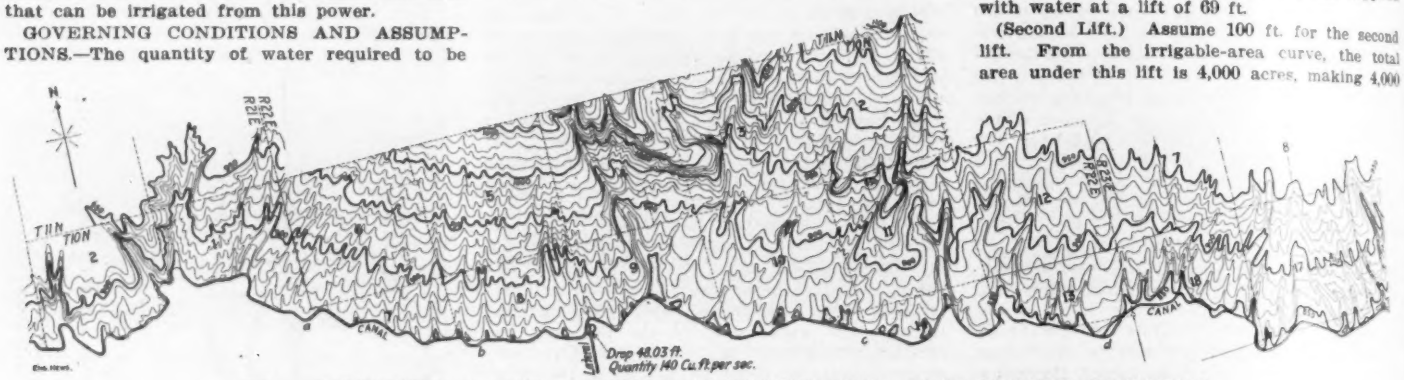


FIG. 1. TOPOGRAPHY OF LAND, ALONGSIDE AN IRRIGATION CANAL; TO BE IRRIGATED BY PUMPING.

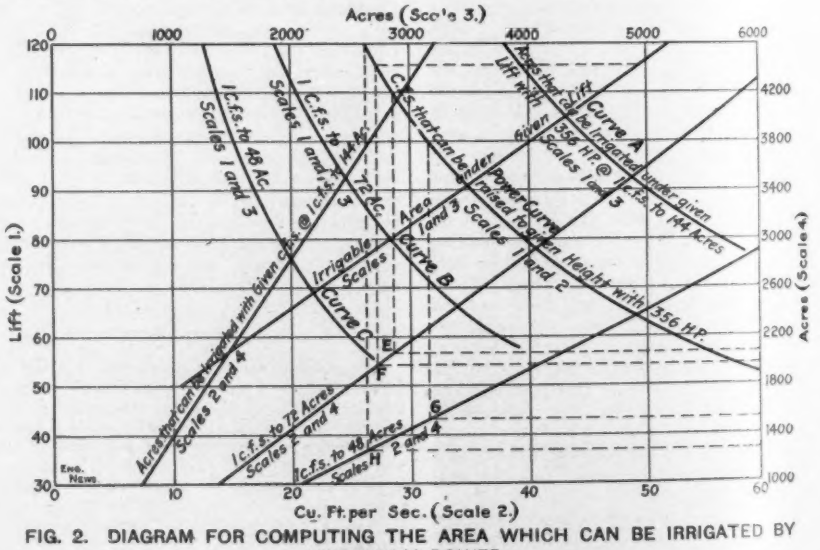

Acres (Scale 3.)
Lift (Scale 1.)
Cu. Ft. per Sec. (Scale 2.)
Acres (Scale 4)
Acres that can be irrigated with given cu. ft. per sec. Scales 2 and 4
1 c.f.s. to 48 Ac. Scales 1 and 3
1 c.f.s. to 72 Ac. Scales 1 and 3
Irrigable Area Scales 1 and 3
Curve B
Curve C
Power Curve raised to given Height with 356 H.P.
Acres that can be irrigated under given Lift with 356 H.P. @ Scales 1 and 3
Curve A
1 c.f.s. to 144 Acres
1 c.f.s. to 72 Acres Scales 2 and 4
1 c.f.s. to 48 Acres Scales 2 and 4
Eng. News

FIG. 2. DIAGRAM FOR COMPUTING THE AREA WHICH CAN BE IRRIGATED BY HYDRAULIC POWER.

(Third Lift.) Assume 120 ft. for the third lift. From the irrigable-area curve, the total area under this lift is 5,200 acres, making 5,200 — 3,770 = 1,430 acres to be watered from the third lift. From the 120-ft. line on the power curve, drop a perpendicular to the duty curve at H and read on scale (4) that 1,250 acres can be supplied. The lift is therefore too high. Trying 117.5 ft., the area is 5,050 acres, making 5,050 —

*U. S. Reclamation Service, Sunnyside, Washington.

3,770 = 1,280 acres to be watered from the third lift. Drop a perpendicular to this duty curve and read on scale (4) that 1,280 acres can be supplied at this lift with the given power.

This process may be continued for any number of additional lifts if desired. The results found above may be tabulated as follows:

	First lift.		Second lift.		Third lift.		Total area all lifts.
Lifts.	Lift.	Area.	Lift.	Area.	Lift.	Area.	
1	105	4,300	....	....	....	....	4,300
2	80	2,850	113	2,000	....	....	4,850
3	69	2,200	96	1,570	117.5	1,280	5,050

The above figures give the theoretical proper adjustment of the available power to the area to be irrigated. When the design of machinery is

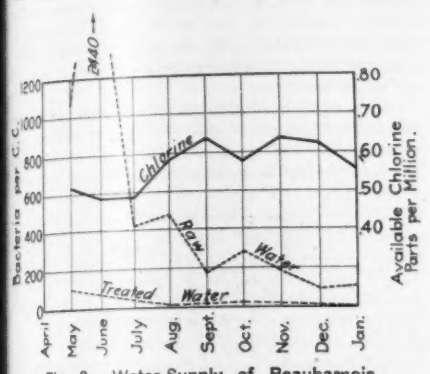


Fig. 3. Water-Supply of Beauharnois.

investigated and the distribution system is laid out, it may be found that the figures determined above must be modified somewhat to adapt them to practical conditions. But in any case they offer an excellent basis on which to work out the final arrangement.

Fusible Pendants to Indicate the Temperature of flue gases have been recently put on the market. The pendants are made of fusible alloys, but do not depend for their indications only upon the melting of the metal at the desired temperature. They are of thin sheet metal, and have a lower portion about ¾-in. square connected by a narrow neck with a circular upper portion, or ring, by which they are to be suspended. In use the pendants are hung from a wire hook introduced into the flue where the temperature is to be measured. Each pendant is stamped with the temperature at which the weight of the rectangular part will pull apart the neck due to the weakening of the metal in the neck by the heat. Pendants are supplied for three different temperatures, 425°, 500° and 550° F. These temperatures represent, respectively, according to the maker, the Green Fuel Economizer Co., of Matteawan, N. Y., the temperature at which the use of an economizer is justified with coal at ordinary prices, the temperature at which an economizer is a good investment in all cases and that at which neglect to install an economizer becomes an inexcusable waste. The best way to use the pendant, according to the makers, is to begin with the lowest-temperature pendant and proceed until the one is found which will not pull apart after five or ten minutes' exposure. The temperature will then lie between the temperature marked on the last pendant and that on the next to the last. From the standpoint of the man who has to pay for the pendants, however, it would seem more advantageous to begin at the other end of the series.

Special Dressed Granite Blocks will be laid on Tottenham Circus, Holborn Borough, London, England. This area is formed by the junction of Oxford, New Oxford and High streets and Tottenham Court and Charing Cross roads. A recent traffic census, according to the London "Surveyor," showed 20,000 vehicles per day passing over the Circus, of which more than 4,000 were motor omnibuses. The granite blocks will replace wood blocks. The size of the granite blocks accuracy of dressing, joint room and jointing material are not stated. The contractor for the granite blocks is the Grey Royal Granite Co., which first supplied these blocks to Croydon, England, but has since supplied them to other British towns.

Water Disinfection by Hypochlorite Treatment in the Province of Quebec.

By JAS. O. MEADOWS.*

Two water-disinfecting plants have been in operation at Montreal for over a year and a half and the results secured have been, on the whole, very satisfactory.† The typhoid fever mortality rate has been considerably reduced, and the city passed through last winter without having typhoid in epidemic form, an experience rather novel and unlooked for in Montreal. Both plants are only temporary, but as an additional factor of safety it is planned to continue the disinfection after the installation of the filtration plants.

The city disinfection plant is under the direction of a skilled attendant, while the Montreal Water & Power Co.'s plant is operated by unskilled attendants under the direction of the Provincial Board of Health. The bacteria in the untreated and treated water at the two Montreal plants are shown by the diagrams, Figs. 1 and 2. Table I. shows the typhoid deaths for Montreal for five years past.

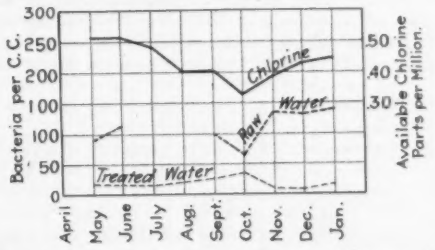


Fig. 2. Plant of the Montreal Water & Power Co.

Hypochlorite plants have also been installed at Beauharnois, Pointe aux Trembles, Shawinigan Falls, Grand Mère and Levis.

The Beauharnois water-supply is secured from the St. Lawrence River, and is polluted by sewage from the municipal sewers. Eddies exist in the river at this point, which carry the sewage over the water intake during certain times in the year. The consumption is 360,000 U. S. gals. per day and the water is treated with .6 parts of available chlorine per million. Good results (Fig. 3) have been secured with this plant, due to efficient operation, and healthy appreciation by the citizens of the merits of a purified water-supply. The plant has not been operated long enough to make any comparative results as regards diminution of typhoid fever, but the reports so far tend to show a decided decrease. This plant, like all the other hypochlorite plants installed in the Province of Quebec, is only temporary, the intention being to later filter the supply or substitute a new supply.

Pointe aux Trembles is located five miles below Montreal, on the St. Lawrence River, and its water-supply is grossly polluted by the sewage from Montreal. The sterilization plant at this place has not been a success, due to irregular operation (see Table II.). The consumption is 90,000 U. S. gals. per day, and the water is treated with .55 parts per million of available chlorine. It is hard to properly regulate the feed of the hypochlorite solution for such a small quantity of water.

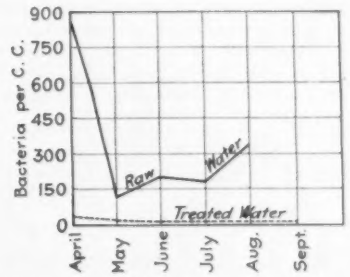


Fig. 1. Municipal Plant at Montreal.

FIGS. 1 TO 3. AVERAGE MONTHLY RESULTS OF WATER DISINFECTION WITH HYPOCHLORITE AT THREE PLANTS IN THE PROVINCES OF QUEBEC.

The sterilization plant at Shawinigan Falls was installed in April, 1911, but scant data are available as regards its operation because of the indifference of the municipal authorities to cooperate with the Provincial Board of Health. The water-supply is taken from the St. Maurice River, ten miles below the city of Grand Mère, and is badly polluted by sewage during the low stages of the river. The consumption is 600,000 U. S. gals. per day and the water is treated with .75 parts per million of available chlorine.

A sterilization plant was installed at Grand Mère last spring to treat a temporary water-supply of a dangerous character. The sterilization of this supply greatly reduced an epidemic of diarrhea which broke out when this supply was first used in its raw state.

At Levis, located across the St. Lawrence River from Quebec, a hypochlorite plant has recently been installed. At this point the river is affected by tides, and the sewage from the city is carried upstream over the municipal intake. The consumption at Levis is 840,000 U. S. gals. per day and the water is being treated with .7 parts per million of available chlorine. Fair results have been secured from this plant so far.

*Sanitary Engineer, Board of Health of the Province of Quebec, 6 Rue St. Jacques, Montreal, P. Q.

†See Eng. News, April 7, 1910, for article by Mr. Meadows describing these plants.

TABLE I.—DEATHS FROM TYPHOID FEVER AT MONTREAL, MARCH, 1906, TO MARCH, 1911.

Months.	1906-07	1907-08	1908-09	1909-10	1910-11
March	13	7	6	12	6
April	4	10	7	7	4
May	5	11	8	6	9
June	4	5	6	7	5
July	4	7	5	7	8
August	11	12	5	9	14
September ..	5	12	14	14	13
October	19	12	16	24	8
November ..	15	12	22	22	11
December ...	18	9	19	53	7
January	19	12	43	78	5
February ...	6	12	9	29	6
Total	123	121	154	267	96
Estimated population	350,538	366,900	380,000	395,000	456,000
Typhoid death rate per 100,000	35.1	32.9	40.5	67.6	21.0

TABLE II.—BACTERIAL COUNTS OF RAW AND DISINFECTED WATER AT POINTE AUX TREMBLES, QUEBEC.

Date.	Bacteria per c.c. 20° C.		Bacteria per c.c. 37° C.		B. Coli.*			
					Raw		Treated	
		Treated.		Treated.	1	10	1	10
1911.	Raw.		Raw.		c.c.	c.c.	c.c.	c.c.
June 24...	2,000	26	1,600	25	3/3	2/2	2/3	2/2
June 28...	9,500	5	2,500	6	3/3	2/2	0/3	0/2
July 5...	5,500	5,000	2,400	2,500	3/3	2/2	3/3	2/2
July 12...	5,500	110	3,000	75	3/3	2/2	3/3	2/2
July 19...	60,000	23	9,800	15	3/3	2/2	1/3	2/2
July 26...	29,000	5	2,600	4	3/3	2/2	0/3	2/2
Aug. 3...	6,500	6,000	5,000	5,000	3/3	2/2	3/3	2/2
Aug. 9...	4,500	2	2,500	6	3/3	2/2	0/3	0/2
Aug. 17...	34,000	140	7,000	15	3/3	2/2	3/3	2/2
Aug. 24...	29,000	25,000	4,500	4,000	3/3	2/2	3/3	2/2
Aug. 31...	5,000	850	2,000	500	3/3	2/2	3/3	2/2

*Examinations for three 1 c.c. and two 10 c.c. portions of raw and of treated water were examined. The numbers in each column at the left of the inclined line indicate the number of samples in which coli. were found; those at the right show the number of samples examined.

The Pavements of New York City are to be considered by a committee of 21 citizens, appointed by Mayor Gaynor. The committee includes representatives of various business and civic organizations, as well as citizens chosen in their individual capacities. The chairman of the committee is Mr. Albert R. Shattuck, of the Automobile Club of America. No engineering societies are represented. The committee is expected "to investigate and report [to Mayor Gaynor] on the present condition of the pavements of the city and how they can best be improved."

Progress on the Strawberry Tunnel of the Strawberry Valley Irrigation Project, Utah, was made in September to the extent of 293 lin. ft. excavated, 1,035 ft. of the arch and sides and 653 ft. of the bottom lining being placed, all of this lining being concrete. A heavy flow of water is still encountered. A letter relating to the trouble with water, from Mr. J. L. Lytel, Project Engineer, U. S. Reclamation Service, Utah, appeared on page 391 of our issue of March 30, 1911. On page 523 of our issue of April 27, 1911, a news-note was published giving the progress made on the tunnel up to approximately that date.

The Dissolved Gases of the Inland Lakes of Wisconsin and Their Biological Significance.*

The most valuable monograph bearing upon the important question of the growth of algae in reservoirs and lakes that has appeared for several years has recently been published under the foregoing title. Although relating to one particular phase of the subject, it opens up the whole question of the vertical circulation of water in lakes and shows relationships hitherto unappreciated between thermal stratification and the distribution of dissolved gases, and the consequent migration of organisms. The report represents the results of an investigation of the Wisconsin lakes that has been going on steadily for many years, an investigation with which few water-works engineers are familiar. The reviewer takes this occasion to bring this important work to the notice of those who are interested in the problem of microscopic organisms in water, and to commend the authors for the patient and careful manner in which they have collected their long series of data. No better summary of the results of their work can be made than is given in their own introduction to the report, from which the following is freely taken.

The lakes studied are of glacial origin, and are relatively small and shallow; the largest has an area of less than 15 sq. mi., and a maximum depth of 237 ft. Most of them have relatively small influent streams and are fed largely from ground water. During the winter they are frozen for several months, and during the summer the surface temperatures rise to maxima of 80° or 85° F. During the spring the temperature is uniform at all depths and near that of the maximum density of water, i. e., 39.2°, the water being constantly mixed by the wind. The advance of summer checks circulation by warming the surface and soon produces thermal stratification. The upper region of circulating waters is called by the authors the *epilimnion*; the lower region of stagnant water is termed the *hypolimnion*; and the intermediate stratum, within which the temperature changes rapidly, is called the *thermocline*. In small lakes this condition becomes fixed in May, but in large lakes stratification may not be complete before July. The epilimnion varies in thickness from less than 10 ft. in small lakes to 35 or 40 ft. in large lakes. During the summer circulation is confined to this layer. As autumn comes on it increases in thickness until the lake is again in complete circulation. After freezing circulation again ceases.

In the spring and fall the lake water, by reason of its circulation, is saturated with gases from the atmosphere. Thermal stratification excludes the lower water from contact with the air, but the water of the epilimnion remains in circulation. While in contact with the air, the water will hold gases in solution in amounts depending upon the temperature of the water, the solubility of the gas and the partial pressure of the gas in the atmosphere.

In addition to these physico-chemical conditions, the gases in the water are influenced by various biological processes that take place in the aquatic animals and plants. Generally speaking, these activities may be divided into two groups: first, those which liberate oxygen and consume carbonic acid, and second, those which liberate carbonic acid and consume oxygen. The first includes the photo-synthetic activities that take place in all chlorophyllaceous plants under the influence of sunlight. The second includes the normal processes of respiration that occur in animal life, and even in plant life in the absence of oxygen, and the decomposition of organic matter that takes place under the influence of bacterial growth. Photo-synthesis, being dependent upon light, is limited to the upper strata of water and is most vigorous near the surface. In very clear lakes it may extend to a depth of 25 ft. or more, but in ordinary lakes it extends only to 10 or 15 ft., and in turbid water it is limited to very much thinner layers. There are thus two principal sources of oxygen, the atmosphere and the oxygen liberated by plant life. To this may be added the small amount that may be obtained from nitrates.

There are four sources of carbonic acid: the atmosphere, ground water, respiration and decomposition of organic matter, and dissolved bicarbonates of calcium and magnesium. The atmosphere seems to afford only a small supply and the same may be said also of ground water under ordinary conditions.

These two gases, oxygen and carbonic acid, are the most important ones from the standpoint of organic life, for while nitrogen may be present in large amounts no evidence has been obtained to show that it materially influences living organisms. In some instances methane, carbon monoxide and hydrogen sulphide have been found in the water at the bottom of the Wisconsin lakes, but the amounts have been small. The present treatise, therefore, deals chiefly with oxygen and carbonic acid.

There are three methods of expressing the results of the analysis of water for dissolved oxygen and carbonic acid: parts per million by weight, cubic centimeters of gas per liter of water, and percent of saturation. The authors have adopted the method of expressing the results in cubic centimeters of gas per liter of water.

Before discussing the data obtained, the fact should be recalled that the solubility of oxygen decreases as the temperature increases and that during the summer water exposed to the air will hold in solution only about half as much oxygen as during the winter. Carbonic acid is more soluble in water than oxygen is, but as the amount of carbonic acid normally present in the atmosphere is small, that is to say, its partial pressure is low, the quantity dissolved in water in contact with air is normally small. Both oxygen and carbonic acid diffuse in water very slowly, so that the presence of these gases in any given volume of water depends upon its exposure to the atmosphere brought about by mechanical or thermal circulation, and upon the production or absorption of these gases by the organisms present. It thus happens that under normal conditions the water near the surface remains saturated with oxygen during the summer, the quantity present being dependent chiefly upon temperature.

In the upper strata photo-synthesis is an important element and acts to a depth which is determined by the transparency of the water. Below this there is a zone where respiration and decomposition predominate, so that the water in the lower layers may lose its oxygen. These functions may occur at all depths, but as dead animals and plants sink in water most of the decomposition takes place in the deeper strata. Hence, the lower layers increase their contents of carbonic acid. It is retained in the upper strata if no growths of algae are present, but if algae growths are abundant near the surface these organisms may use up not only all the free carbonic acid present, but may take it away from the bicarbonates, thus giving the water an alkaline reaction.

These changes in dissolved oxygen and carbonic acid are well illustrated by Figs. 1 and 2, which shows the results of observations made at Lake Mendota, Wis., during 1906 and 1907. In these diagrams the quantity of gas is shown by the ordinates in cubic centimeter per liter, while the different lines represent different depths in meters. It will be seen from Fig. 1 that during the spring the water was at all depths saturated with oxygen and that as summer advanced the oxygen decreased much more rapidly at the bottom than at the surface of the lake, disappearing altogether by the first of July and remaining absent throughout the entire summer. During the fall aeration extended progressively downward until at the time of the autumnal overturn the water again became completely saturated.

The carbonic acid during the early spring was the same at all depths. On account of the growth of algae, it soon disappeared at the surface and the water became alkaline. This alkalinity, expressed in the diagram by the negative carbonic acid results, increased at the surface until July, after which it decreased until the fall overturn, when the water became practically neutral. The conditions at the bottom

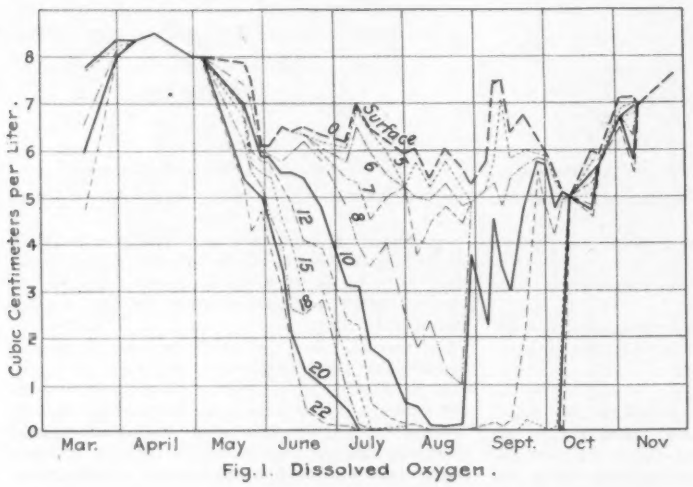


Fig. 1. Dissolved Oxygen.

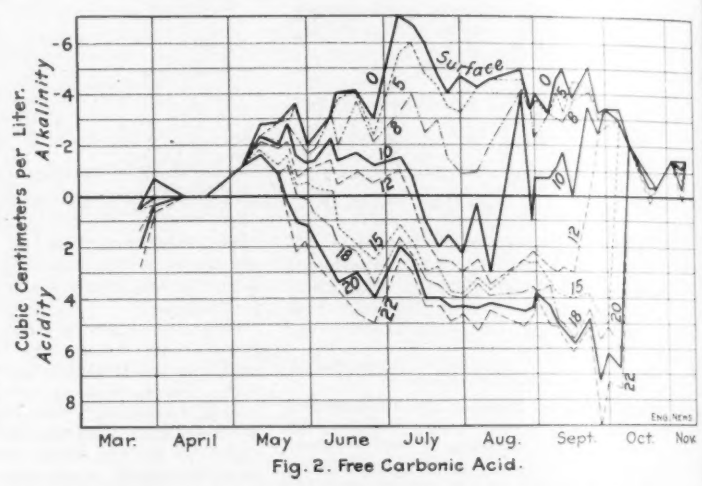


Fig. 2. Free Carbonic Acid.

FIGS. 1 AND 2. DISSOLVED OXYGEN AND FREE CARBONIC ACID AT DIFFERENT DEPTHS IN LAKE MENDOTA, WIS., AS OBSERVED IN 1906-1907.

(The depths indicated on the curves are in meters and should be multiplied by 3.281 to give equivalent figures in feet.)

*A monograph by Dr. Edw. A. Birge, Director, and Mr. Chauncey Juday, Biologist, of the Wisconsin Geological and Natural History Survey. Bulletin No. XXII, Scientific Series No. 7, 1911 [of above-mentioned survey]. Madison, Wis.: Pub. Doc. 7½ × 10 ins.; pp. 259; 10 plates and 142 figures.

An abstract with appreciative comment by George C. Whipple,† M. Am. Soc. C. E.

†Consulting Civil Engineer, 103 Park Ave., New York City.

were quite different. From the middle of May onwards until the autumn the amount of carbonic acid steadily increased in the water below the thermocline, due to decomposition and respiration. At mid-depth the carbonic acid fluctuated considerably during the summer; for about two months the water was alkaline, then slightly acid, then alkaline again.

It will thus be seen that when thermal stratification and the conditions affecting the occurrence of dissolved gases in water are taken into account, it is possible for very many different conditions to be found in different lakes. There is good reason to believe that these conditions modify profoundly the growth of algae and other aquatic forms of life, and a wider study of these conditions ought to add much to our knowledge of the whole subject.

The observations made by Messrs. Birge and Juday show that super-saturation of water with oxygen very commonly occurs as a result of the activities of plant life. This has been noticed by others, but never have the results been shown in such a convincing manner as in this report. The amount of oxygen found was very often more than 50% in excess of that required for saturation, while in some instances double and even treble the amount required for saturation was present. This condition was found less frequently at the surface of the water than at a depth just below that of the circulating water; that is, supersaturation occurred in the region of the thermocline. When such water was brought to the surface it was sometimes found to effervesce freely. This supersaturation at the thermocline is interesting when taken in connection with the fact that certain algae are often found concentrated there. The authors give frequent illustrations of this fact and it has been noticed by many other observers.

The power of algae to utilize the carbonic acid and bicarbonates has never been so clearly set forth as here. It is interesting to notice, as a corollary to this proposition, that in Wisconsin the hard-water lakes apparently support larger growths than do the soft-water lakes, a fact already found to be generally true of the water-supplies of Massachusetts. Further, the same phenomenon tends to cause the precipitation of calcium carbonate, as the normal salt is much less soluble in water than the bicarbonate. Thus these biological processes of the algae have an influence on geological deposits.

The authors are modest in drawing conclusions from the data thus collected, appreciating, as everyone must who has carefully studied the question, that very many factors are involved in the occurrence of algae growths in lakes and reservoirs.

Petroleum Products in the United States for 1910 had a total value of $236,998,000, according to a census bulletin recently issued. This is an increase over the value of the products in 1904 of 35%. During the same five-year period the amount of capital invested increased 33%, and the cost of materials 43%. There were 98 establishments in 1904 and 147 in 1909, an increase of 50%. The average product of each establishment in 1904 was $1,786,000, and in 1909 $1,612,000. The salaries and wages increased but 8% between 1904 and 1909, the totals being $12,713,000 and $13,738,000, respectively. The number of salaried officials and clerks increased 35%, but the number of wage earners decreased 17% due chiefly to the fact that in this census the large refineries made separate reports for their box, cooperage and tin ware shops, so that the employees of these shops are not included as they were in the former report. There was an enormous increase in the amount of crude oil produced, 66,983,862 bbls. in 1904, and 120,775,439 bbls. in 1909, an increase of 80%. These figures are for 42-gal. bbls. The following table gives the amount of refined products for the two years:

	Quantities (bbls. of 50 gals.)		Per cent.
	1909.	1904.	increase.
Illuminating oils	38,468,494	27,135,094	42
Fuel oils	34,034,577	7,209,428	372
Lubricating oils	10,745,885	6,298,251	71
Greases (lubricating, etc.)	138,302	202,439	*32
Naphtha and gasoline	11,903,159	5,811,289	105
Paraffin wax	946,830	794,068	19

*Decrease.

Harbor Development and Improvement at Montreal, Canada.

The city of Montreal affords a very striking instance of harbor development carried on consistently and steadily for the purpose of promoting commerce and keeping abreast of, if not in advance of, modern conditions and requirements of the shipping trade. The city is the principal port of Canada, although it lies far inland and is open to navigation for only about seven months each year.

Montreal, on the St. Lawrence River, is nearly 1,000 miles from "blue water" or the open Atlantic, beyond Newfoundland, and for many years this condition hampered the development of its shipping trade owing to the dangers of navigation. Of late years, however, much has been done by the introduction of lighthouses to render navigation safe and convenient, while very extensive improvements have been made also in the 150-mile stretch of the river from Quebec to Montreal. The city is located at the limit of navigation for ocean vessels, as just above are the numerous rapids. On the other hand, a canal system available for vessels of 14-ft. draft affords communication with the Great Lakes, so that Montreal occupies a strategic position at the meeting point of ocean and inland navigation. It is also the principal point on two of the leading railway systems of Canada, and in a few years will be served by three trans-continental lines, all developing the great areas and resources of the Canadian northwest.

Within ten years the foreign trade of Canada has increased from $381,661,000 (1900) to $693,211,000, or nearly 100%. The imports and exports of Montreal for the seven months of 1910 amounted to $262,685,000 and $158,121,000 respectively, while the customs revenues were $10,833,191. While the number of vessels has increased steadily, the tonnage has increased much more rapidly, owing to the growth in size of ocean steamers. In 1910, there were 719 sea-going vessels and 310 lake vessels; these (with a few small craft) represented a total of 2,562,876 registered tonnage. The port is accessible to vessels of 12,000 tons, and will be accessible to vessels of 18,000 tons on the completion of the work of dredging the ship channel in the river from 30 ft. to 35 ft. in depth.

The development of the harbor of Montreal may be said to date from 1825, when the first Lachine Canal was opened, thus making Montreal the meeting point of ocean and inland navigation. This canal had a depth of only 4½ ft. on the sills. Between 1841 and 1848, all the canals of the St. Lawrence canal system were completed, giving a 9-ft. waterway for the 300 miles from Montreal to Lake Erie. Subsequent improvements have resulted in giving a waterway capable of accommodating vessels of 14 ft. draft and 2,500 tons cargo capacity.

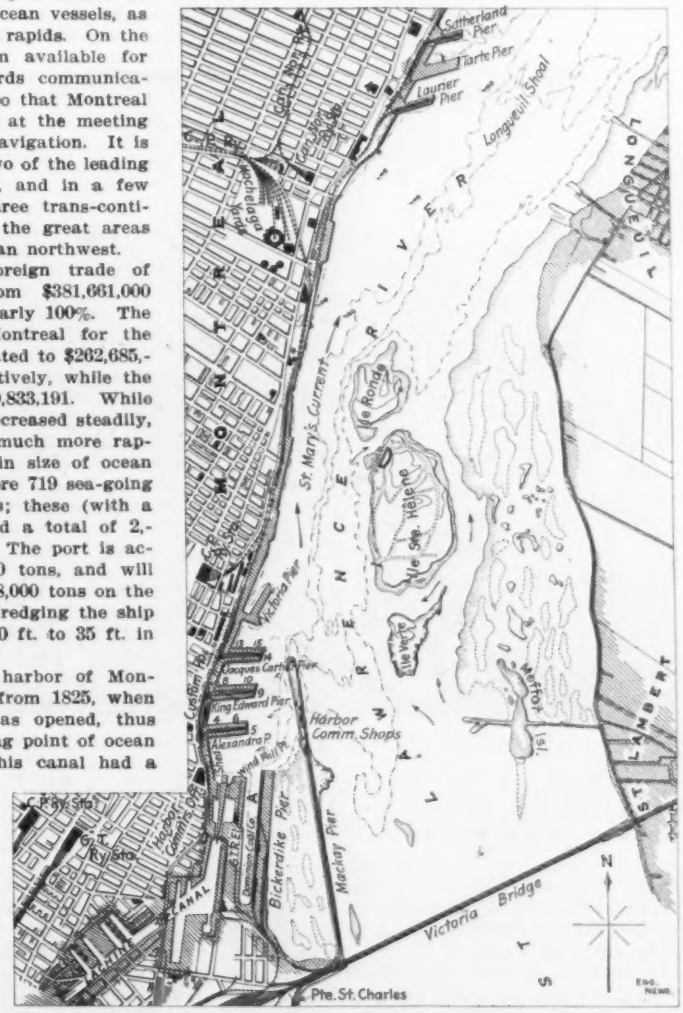


FIG. 1. PLAN OF HARBOR OF MONTREAL (QUEBEC), CANADA.

The harbor is closed by ice for about five months, but ice-breaking steamers are used to keep the river open as long as possible in the winter and to open it as early as possible in the spring. The spring floods have in earlier years caused much damage to the city and harbor, both by the water (backed up by the ice) and by the "ice shoves" or irresistible movements of the masses of ice piled up on the shore. These damages have been reduced materially by building the new piers and wharves about 13 to 15 ft. higher than the old ones, which latter will be raised also to the new level. A flood wall along the shore side of the harbor property protects the city from inundations. The following are the elevations above the datum or zero line, which is the lower sill of old lock No. 1 of the Lachine Canal:

	Ft.	Ins.
Extreme low water	13	0
Ordinary summer level	17	0
Ordinary spring flood level	36	6
Highest water (1909)	37	7
Highest flood level (1886)	44	4
Low level wharves	23 to 25	
High level wharves	38	0
Floors of new pier sheds	42	0
Top of flood wall	46	0

The administration of the harbor is in the hands of the Harbor Commissioners, a body composed of three members who are appointed by the government. Its work, so far as expenditures are concerned, is subject to the approval of the Minister of Marine and Fisheries, whose department also has control of the St. Lawrence River, its improvement and navigation. The jurisdiction of the commission extends along the river for a distance of 17 miles, including both banks, but it does not include the ship channel, which is under direct control of the government. The commission holds in trust from the government all harbor lands and areas, including about 12,000 acres of water and 187 acres of improved or reclaimed land. There is no charge for navigation, but the revenue of the commission is derived from wharfage rates on freight and from the rental of warehouse and pier accommodation. Mr. George W. Stephens is President of the Board of Harbor Commissioners; Mr. John Kennedy, M. Inst. C. E. and M. Am. Soc. C. E., is Consulting Engineer, after holding the position of Chief Engineer from 1875 to 1907; Mr. Frederick W. Cowie, M. Inst. C. E., is Chief Engineer.

The first Harbor Commissioners were appointed in 1830, by the Province of Lower Canada. The works then undertaken were planned by Major Robert S. Piper (Royal Engineers) and Mr. Peter Fleming, C. E.; they included wharves, slips, and a revetment wall. The appropriations for the first three years amounted to $405,000, but no further appropriations were made, the

revenue was disappointing, and the port dues were evaded. The navigation was limited to vessels of 10 ft. draft by the shallow channel of the wide portion of the river known as Lake St. Peter, 60 miles below the city. Between 1830 and 1873, numerous plans, for harbor improvement were submitted by different engineers, including Sir Casimir Gzowsky, T. C. Keefer, John Trautwine, and others. In 1875 the government appointed a board to report upon the matter, consisting of Mr. Robert B. Bell, Mr. Sandford Fleming and Maj. Gen. Newton. No definite action resulted from the report of this board, and the same fate attended a project for water power development and harbor extension proposed in 1880 by Messrs. Bateman and Shearer. In 1886, there was appointed the Montreal Flood Commission, to consider means for protecting the city and the harbor from floods and flood damages. The commission was composed of Messrs. John Kennedy, T. C. Keefer, P. W. St. George and H. F. Perley.

In 1888, a general scheme of river improvement and the construction of piers and warehouses was proposed by Mr. John Kennedy, M. Inst. C. E., and this has been carried out practically as planned. In 1895, he proposed an extensive scheme of improvement of the shipping accommodation and the freight handling facilities, which was adopted by the Harbor Commissioners. All these improvements were practically completed in 1909, at which time plans were made for another large scheme of improvements which will be noted later.

In the execution of the harbor works, financial conditions did not permit the adoption of masonry construction for piers, and only to a limited extent for bulkhead walls, while the ample supply of timber and the fresh water of the river made timber construction both cheap and permanent (for submerged work). Timber cribbing, with filling of rock and earth dredgings, is the standard type of construction, but concrete is now being used instead of timber for the face work above the low-water level. In all the new work, consideration has been given to permanence of construction, conformity to a general scheme, probable future requirements, and means of intercommunication by water between all parts of the harbor. There are no dry docks, but provision has been made for a floating drydock and ship repair plant, as noted later. The river walls or bulkhead walls were built in deep water, and the space behind them was filled in as made-ground for the sheds and other facilities.

The total expenditures on the harbor up to the end of 1908 were about $10,000,000. In 1909, the government authorized the expenditure of $2,000,000 a year for three years to provide additional works.

The Ship Channel.

The navigable depth of the St. Lawrence River between Montreal and Quebec was limited originally to 10½ ft. at low water by certain bars and by the flats of Lake St. Peter. It has now been deepened to 30 ft. throughout, except at some bars in the tidal part of the river which give a depth of 27½ ft. at lowest tides and at which the deepening to 30 ft. is not yet completed. There is no tidal effect above Three Rivers (about 80 miles below Montreal), but the water level has a range of 10 to 12 ft. between low water in the autumn and high water in the spring; a maximum rise of 28 ft. is due to ice in the winter. The improvement of the channel by dredging was commenced in 1844. This work was not unlike that on the Clyde in Scotland and the Tyne in England, where important ports have been established on what were originally shallow and insignificant streams. In the improvement of the St. Lawrence, however, the work was on a vastly larger scale as to the length and width of the river. The length of river requiring dredging was about 50 miles and by 1888 the depth over this distance had been increased to 27½ ft. under the direction of the Harbor Commissioners of Montreal.

In 1888, the Canadian government assumed the work and also the debt incurred for its execution up to that time, recognizing that the ship channel was of national importance and not merely for the benefit of the city of Montreal. In 1899, the government undertook to increase the channel depth to 30 ft. at low water; to widen and straighten the channel, and to mark it by lights, buoys, ranges and other means so as to facilitate navigation by day and night. In 1907, the improvements were completed, except at certain places in the tidal part of the river, where the rise of water, however, gives the full desired depth; the minimum recorded depth that season (at low tide at these places) was 37 ft. 10 ins. This work for the improvement of navigation in the St. Lawrence was described in our issue of July 28, 1904, and details of the cost of dredging were given in our issue of Jan. 30, 1908. In 1909, the government commenced work on a further scheme for increasing the channel depth to 35 ft., and it is expected that this will be completed in 1912.

The work on the 30-ft. channel is about 60 miles long, and has a width of 450 ft., which is increased to 550 or 650 ft. on curves. The curves are easy, and are marked by buoys and range lights. Gas buoys are used extensively. The sharpest curves are of 9,240 ft. and 13,200 ft. radius on the inner line of the channel, with included angles of 26° and 52° respectively. The tangents of the outer line extend beyond the P. C. of the inner line and are connected by a curve of 7,920 ft. radius. This gives a maximum width of 600 ft. and 650 ft. respectively at the center of the main curve. Opposite the city there is a depth of 30 ft. for a width of about 1,000 ft. from the bulkhead line on the north shore. In the harbor, the ship channel is made and maintained by the dipper dredges of the Harbor Commission, under arrangement with the government. Beyond this the work is done mainly by large hydraulic dredges; one of these was described in our issue of July 28, 1904.

FIG. 2. THE HARBOR OF MONTREAL; LOOKING DOWNSTREAM FROM THE GRAIN ELEVATOR OF THE GRAND TRUNK RY. (POINT A, FIG. 1).
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[In the foreground is the Windmill Point Pier, with the gallery of the shipping conveyor from the Grand Trunk Ry. elevator. At the left are the entrance locks of the Lachine Canal, and beyond is a steamer lying at one of the bulkhead sheds. The other steamer is lying at the first of the three new piers, beyond which is the grain elevator (No. 1) of the Harbor Commissioner. On the sheds of the piers and bulkheads are the galleries for the conveyors from this elevator. The white spot beyond the piers is the Harbor Commissioners' elevator (No. 2), and to the right of this the Canadian Pacific Ry. elevator.]

These improvements not only made Montreal accessible for the largest class of ocean steamers but provided safe navigation by day and night. The latter feature was specially important owing to the fact that the St. Lawrence River route for transatlantic service had been given a bad reputation. The results of the improvement works are evident in the enormous increase in the shipping trade during the past few years. This applies to passenger as well as freight service, and a number of transatlantic lines now operate steamers to and from Montreal.

The Harbor.

The harbor facilities are provided entirely along the north bank of the river, and mainly within a distance of about 4½ miles from the Victoria Bridge. In early days, all vessels lay alongside shore wharves, but now the shipping facilities include both shore wharves and piers; the latter project into the stream at a slight angle downstream in order to facilitate the handling of vessels. Fig. 1 is a plan of the harbor, and Figs. 2 and 3 are views from points (A) and (B) on the plan. The latest facilities include a group of three large piers at the upper end of the harbor. These are the Alexandra, King Edward and Jacques Cartier piers; they are used by the passenger steamers of several transatlantic

lines. In front of these piers is the lower end of a solid embankment (the Mackay Pier), 1½ miles long, extending downstream from the north abutment of the Victoria Bridge. This forms a still-water basin, protected from the current of the river, so that steamers can be handled readily and safely in approaching and leaving the piers. In the upper part of this basin is another shorter pier parallel with the stream; this is the Bickerdike pier, with berths for steamers delivering coal and loading grain cargoes. Below it are the entrance locks of the Lachine Canal. The space between the Mackay and Bickerdike piers may be utilized later for additional piers above and at right angles to these now existing.

Below the new piers is the older Victoria Pier, used chiefly for river and coastwise steamers. From the Victoria Pier to Hochelaga, a distance of nearly two miles, the river channel is too much restricted by St. Helens Island and other islands to permit of piers, and here are located the shore wharves, which are used by steamers and vessels of all kinds. Below Hochelaga there is another group of three piers; these are the Laurier, Tarte and Sutherland piers, which are used mainly by freight steamers. Below these, there are several shore wharves, distributed over a distance of about three miles downstream.

Trouble with ice has been an almost annual occurrence, the "ice shoves" forcing it high over the wharves and smashing or wrecking all superstructures. For this reason, some of the warehouses were of temporary construction and were removed each season when navigation closed. This difficulty has been reduced, however, by raising the level of the wharves and old piers to that of the new piers, which is about 25 ft. above low water.

New Piers and Freight Sheds.

The recent improvements at the upper end of the harbor, plans for which were adopted in 1898, include two piers 1,000 ft. long and one 850 ft. long, all 300 ft. wide and separated by slips 550 ft. wide; also 14 steel-frame freight sheds, two grain elevators, and other auxiliary works.

The piers are of solid construction, having walls of timber cribbing, built of squared face timbers and round tie timbers. The cribs are 57 ft. high, 42 ft. wide at the base and 14 ft. at the top. Some of them are founded on the rock and others on hard silt, at a depth of 32 ft. below low water. No foundation piles were used. The filling is of rock for the front compartment of the cribbing, and a considerable part of the second compartment, up to high water level. The remainder of the cribbing, and the entire width of the pier between the crib wall, is filled with rock and earth dredged out of the slips between the piers and out of the neighboring channels and basins. In this way, the deepening of the harbor was utilized in the construction of the piers. The cribwork walls are strengthened against the earth pressure by two rows of 1½-in. tie rods, spaced about 10 ft. apart; these reach from the face timbers (near the water line) to about 60 ft. back in the filling, where they are secured to timber anchorages. The length of the rods is 24 ft. in the top row and 64 ft. in the lower row.

A plank floor 11 ft. wide extends from the edge of the pier to the shed. The shed floors are of concrete, and are 3 ft. 6 ins. above the general pier level. The roadways and the railway tracks between the sheds are paved with scoria blocks laid on concrete.

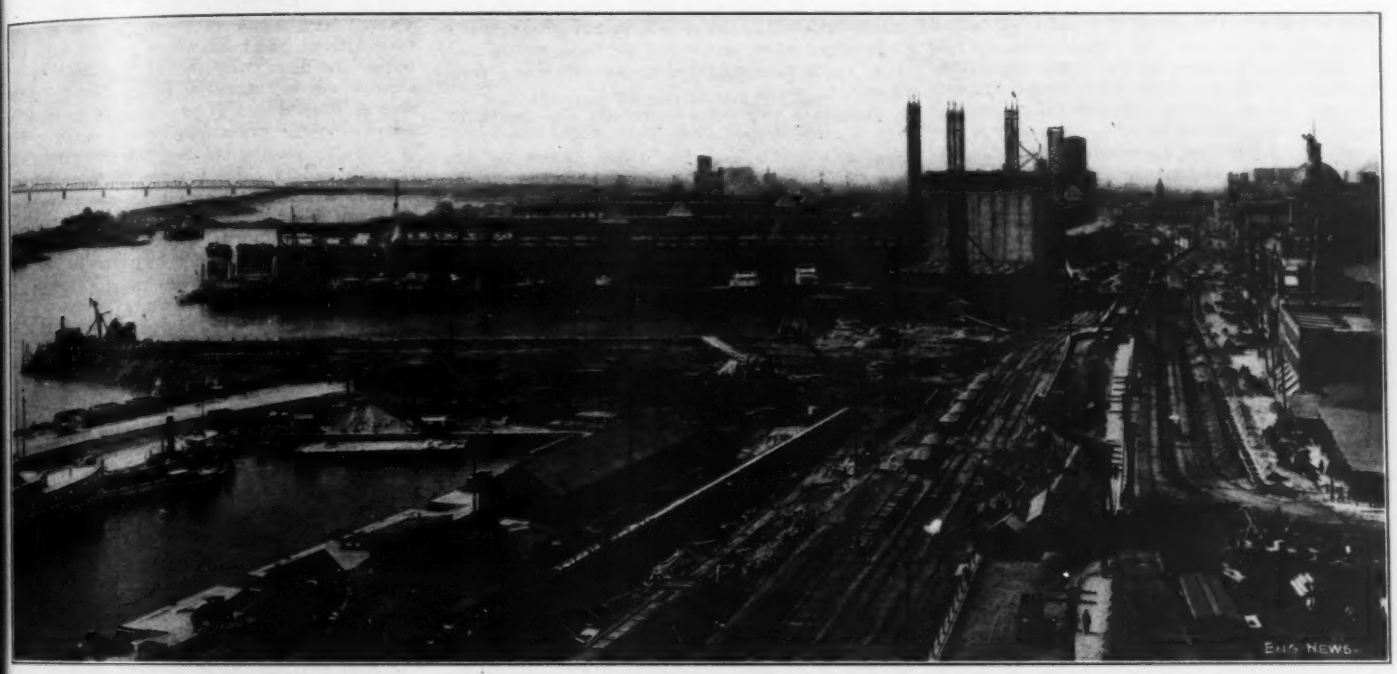

FIG. 3. THE HARBOR OF MONTREAL; LOOKING UPSTREAM FROM THE GRAIN ELEVATOR OF THE CANADIAN PACIFIC RY.

(Copyright 1911; W. H. Notman & Son, Montreal.)

[To the left are the Victoria Bridge and the Mackay Pier (or guard pier) extending downstream. In the center is the grain elevator (No. 2) of the Harbor Commissioners, and the construction work shown in progress is for the pier at which lake steamers will lie to discharge grain for this elevator. Beyond is elevator No. 1, and to the left is the elevator of the Grand Trunk Ry. Beyond the steamer are three of the floating elevators. In the foreground are the elevated tracks of the harbor railway, with the concrete flood wall at the right, separating the driveway from the street. The inclined driveways lead from the street level to the subways.]

The bulkhead crib wall is practically the same as that of the piers up to the low water line, except that the spaces between the cross tie timbers of the front compartments are filled with timber so as to make a solid timbering to assist the face timbers in carrying the concrete wall above. The wall of the cribbing is anchored by 3-in. tie rods, to assist in resisting the horizontal pressure of the earth in the rear. These rods are 14 ft. apart horizontally, and about 16 ft. below the top of the wall. They extend back about 64 ft., and each is secured to a concrete block 8 × 8 ft., 3 ft. thick, set on edge and embedded in the filling. The concrete wall in front of the elevator, which is some 30 ft. in width and carries two marine towers for unloading vessels, rests in front on the cribwork and in the rear upon the foundation walls of the elevator. It is of cellular construction, and is covered by a thick concrete slab in which are laid the rails for the traveling marine towers.

Each side of the pier is occupied by two freight sheds, or rather by one long continuous shed divided into two parts by a concrete partition wall. Two tracks are laid along the inner side of each shed, and the intervening space forms a roadway which is about 45 ft. wide clear of the tracks. The whole space between the sheds is covered with a concrete foundation floor 8 ins. thick under the tracks and 5 ins under the roadway. Upon this is laid a paving of scoria blocks the tops of which are flush with the tops of the rails. The blocks are laid on a 2-in. bed of cement mortar (1:2), and the joints are filled with cement grout. This makes a smooth even floor from shed to shed, suitable for trucking or for wagons, and giving access to the sides of the sheds for either wagons or railway cars as may be needed.

At some of the sheds there is a railway track on the 11-ft. planked space on the water side of the pier. On the remaining piers the floor slab is extended 3 ft. outwards from the side of the shed and supported on steel cantilevers in order to form a platform for more conveniently landing freight from the steamers.

The wharf or shore line property at this part of the harbor is separated from the adjacent city street by a cut-stone wall about 7 ft. high, which protects the lower part of the city from being flooded when the river is raised to excessive height by ice jams. The space between the flood wall and the bulkhead is from 210 to 250 ft. in width. Next to the bulkhead are freight sheds and the Harbor Commissioners' grain elevators, the remaining portion of the width being occupied by railway tracks and roadways. Along the flood wall is a 30-ft. roadway, and next to this are two railway tracks; two of these are main tracks, forming part of the harbor railway system, and the others are reserved for switching ond standing cars. All are connected to the spur tracks leading to the piers by means of frequent crossovers; other spurs and sidings lead to the elevators and to the sheds along the bulkhead.

The entire space between the flood wall and the bulkhead and the piers (except that occupied by buildings) is paved with granite blocks, this paving being flush with the tops of the rails and with the paving of the adjacent street, and also flush with the scoria block paving of the piers. In this way the entire area not actually occupied by standing or moving cars is available for wagons. The roadways and railway tracks are carried through the flood wall at frequent openings, these being closed by watertight gates at time of flood.

FREIGHT SHEDS.—Of the 14 new freight

sheds, there are four (in two rows) on each pier, and two on the bulkheads between the piers. They are double-deck sheds of uniform design, having a width of 96 ft. and a length varying from 365 ft. to 650 ft. They are of steel frame construction, with floors and roofs of reinforced concrete (monolithic) and the walls of corrugated iron sheeting. The foundations are groups of piles driven in the filling of the pier, and supporting concrete footings and pedestals. In seven of the sheds, wood piles 20 to 30 ft. long and 10 to 15 ins. diameter were used; these have an average load of 25 tons per pile. In the other sheds, Raymond concrete piles were used; these are about 17 ft. long, 19 ins. top diameter, and carrying loads of 30 to 50 tons each.

The steel structure has four rows of columns, those of the two outer rows 21 ft. apart, and those of the inner rows 42 ft. apart. They are spaced 15 ft. 10 ins. longitudinally, except that in the upper floor the alternate columns are omitted, giving a spacing of 31 ft. 8 ins. for the columns which support the roof trusses. The outer rows of columns are not in the line of the walls, but are placed 6 ft. inwards, so as to give clear openings at any point for ships' gangways on the outer or water side and for car doors and wagons on the inner side of the lower story. In the first story each column is composed of an I-beam (8 × 6 ins.) and two 12-in. channels; those of the upper story, are composed of pairs of 12-in. channels with lattice bars over the flanges. The floor beams are plate girders, 40 ins. deep in the central span and 36 ins. deep in the side spans. Between these are 20-in. I-beams 7 ft. apart.

On the outer sides of the sheds at which there is no railway track between the shed and the edge of the pier, the lower floor is extended on cantilever beams for 3 ft. beyond the line of the shed, so as to serve as a landing stage. The transverse girders of the upper floor also are carried out as cantilevers to support the 2½ ft. extension of this floor and to carry longitudinal lattice girders to which are attached the runways for the sliding doors of the lower floor directly under the doorways and walls of the upper floor. On the land side of the shed, the transverse beams of the upper floor extend 6 ft. beyond the outer rows of columns, to carry similar lattice girders to which are attached the runways of the sliding doors, which are directly beneath the doors and walls of the upper floor, as on the other side.

The roof over the central span is supported by 42-ft. trusses; the top chords of these (each composed of two 9-in. channels) extend over the side spans, and have knee-brace connections to the columns. From the projecting ends of these channels (over the cantilevered floors) are suspended the trusses of the upper floor. Five lines of 20-in. I-beam purlins (over the columns and at the ridge) carry 9-in. I-beam rafters spaced about 5 ft. 3 ins. apart. There is no continuous monitor roof, but in each roof panel there is a raised skylight 10½ × 24 ft., with a height of 5 ft. This is fitted with hinged sashes. On the water side of the sheds the roof carries the steel framing of the gallery for the grain conveyor system.

The lower stories have no walls, but are closed by the rows of continuous sliding doors, so arranged as to allow of being opened at any point. On the upper stories the walls or sides are galvanized corrugated sheets attached to a light steel framing by means of hook bolts. This siding, however, occupies only every alternate panel, the remaining panels being closed by sliding doors, each forming a complete panel. On the lower floor, there is a door to each panel, while in the upper floor they form alternate panels. The two floors and the roof are of concrete (1:2½:5) 7 ins. thick, and reinforced with wire cloth. The finish is formed simply by flushing the cement to the surface, but the inclined approaches for teams are paved with granite blocks. The roof is covered with felt laid in an asphalt composition. The structural steel, sheathing, etc., are painted with three coats of oil paint, the color of the finishing coat being light gray. The upper floors and the roof are designed for live loads of 600 lbs. and 45 lbs. per sq. ft. respectively. The concrete of the lower floor is on the solid filling of the pier, and therefore will carry any weight. Teams are driven directly into the lower floor. One pier has an electric elevator with platform large enough to take a 5-ton wagon and its team to the upper floor.

Grain Elevators.

Canada is a great producer and shipper of grain, and an enormous expansion of this business is in view with the development and settlement of the Northwest. Special attention has been given, therefore, to the handling of grain at Montreal, where it is received by rail, by lake vessels and by canal boats, and where the bulk of the grain received is delivered to ocean steamers for shipment. In 1910, there were 31,191,500 bushels of grain of all kinds received at Montreal (20,239,400 bushels of wheat), of which 27,959,400 bushels (including all the grain) were exported. The wheat shipments increased from 10,199,000 bushels in 1899 to 28,300,000 in 1908, but then fell off somewhat to 26,000,000 in 1909 and 20,239,400 in 1910. The reduction is said to have been due to specially low rates offered for lake transportation to Buffalo and for ocean shipments from American ports.

There are two grain elevators, one owned by the Harbor Commissioners (who are now building a second), and the other owned by the Grand Trunk Ry. (See Fig. 1.) The former serves a system of belt conveyors by which grain can be delivered to ocean steamers while lying at their regular berths at all the fourteen sheds above described, and without interference with the handling of general cargo. The latter has conveyors also, but these serve only the berths adjacent to the elevator, so that ships must be moved to these berths to receive grain cargo. The Commissioners own several floating elevators for taking grain from lake vessels or canal boats and loading it directly into ocean steamers. The largest of these can load from 12,000 to 15,000 bushels per hour; these have hulls 100 × 30 ft., carrying machinery, towers, legs, spouts, etc. Formerly the floating elevators were operated by private firms; the use of this system has decreased, however, owing to the greater rapidity and facility afforded by the new land elevators and the conveying system.

THE HARBOR COMMISSIONERS' GRAIN ELEVATOR.—The grain elevator No. 1, now in use, is of steel construction with 36 cylindrical bins 21 ft. in diameter and 85 ft. high. Curved sheeting between the outer walls of adjacent bins forms small exterior bins, while most of the interior intermediate spaces are also used as bins. Four of these latter spaces, however, are left open for the reception of the operating legs. The building is 190 × 84 ft., with pile foundations capped by a heavy slab of reinforced concrete, while concrete beams and columns support the steel superstructure. The storage capacity is nearly 1,000,000 bushels, and the elevator handled 8,660,000 bushels in 1908, and 11,554,000 in 1909. Above the bins is a structure containing the distributing floor and cupola, the latter being 42 × 67 ft.

The receiving tracks pass through the building (beneath the bottoms of the bins), and the railway cars discharge the grain into large receiving hoppers beneath these tracks; four elevating legs raise the grain to 1,600-bushel garners in the cupola, from which it falls to scale hoppers of similar capacity, and from the scales it is delivered to belt conveyors. The grain may be loaded directly into cars or vessels at the elevator by means of spouts, but nearly all of it is delivered to vessels at their berths by means of a system of belt conveyors extending over the sheds on the piers and bulkhead walls.

Two special features of the elevator are the traveling marine towers for unloading grain from lake steamers and barges, and the belt conveyors for loading grain into ocean steamers. The two towers are nearly alike, the second having been built in 1910. Each is of structural steel and about 150 ft. high. It is mounted on four trucks which travel on a double track on the cellular concrete bulkhead wall, the construction of which has been described already. The marine leg is suspended from the top of the tower, and when not in use it is housed entirely within the tower. It can be lowered 67 ft. and the bottom can be swung out 20 ft. from the side of the bulkhead wall so that it can reach and fully unload the largest steamers. The grain discharged at the top of the marine leg is delivered to a garner feeding a 200-bushel scale hopper, and falls then to a second garner from which it is delivered by spouts to the receiving hopper of the main building.

To obviate the delay and inconvenience of moving ocean steamers from their berths to the elevator, a conveying system has been installed. In each direction from the elevator a belt in a conduit along the wharf extends to a tower at the corner of the adjacent pier, where elevator legs raise the grain to the level of galleries which extend across the end of the pier (at an elevation of about 60 ft. above high water), and along each side of the pier and the adjacent bulkhead wharves. The latter galleries are upon the roof of the sheds, as described above. These galleries (which may be seen in Figs. 2 and 3) have loading spouts 62 ft. apart, and the grain may be discharged by any of these by placing the belt tripper at this point. In each gallery there are two 36-in. rubber belt conveyors, and there are in all about five miles of these belts. Each belt can deliver 15,000 bushels per hour, making a total capacity of 60,000 bushels per hour, which can be delivered simultaneously to four ships lying at any one of the 14 freight sheds. This conveyor system is operated by 31 electric motors aggregating 1,735 brake HP., while the elevator machinery is operated by 13 motors aggregating 925 HP.

Grain elevator No. 2 for the Harbor Commissioners was commenced in 1910, and is shown under construction in Fig. 3. This is located on the wharf between the Jacques Cartier and Victoria piers. It has a roadway on the water side and railway tracks at the rear. A small pier or jetty is built out from the bulkhead wall, on which will be operated two traveling marine towers, so that two of the largest lake steamers lying at this pier can be unloaded simultaneously. The bins, walls and and floors are of reinforced concrete. It is 314 × 100 ft. in plan, and has a storage capacity of 1,772,000 bushels. It is founded on wood piles covered with a 3-ft. slab or mattress of concrete. In addition to loading in grain from lake vessels it will be able to receive grain from 28 cars at once, seven cars on each of the four tracks which run through the building. This is equivalent to 280 cars per day, or approximately 280,000 bushels. There will be an extension of the conveyor system also, so that the elevator can serve any one of the 20 berths between the Victoria Pier and the Lachine Canal.

GRAND TRUNK RY. ELEVATOR.—This elevator is at the upper or west end of the harbor, on Windmill Point pier; it has the entrance lock and basin of the Lachine Canal on one side, and a deep water basin on the other side with loading berths for two ocean steamers. The two railway tracks enter the building for cars to be loaded and unloaded. On the canal side are legs and spouts for unloading or loading barges in the lock basin. On either side is a gallery for belt conveyors delivering to a row of spouts for loading ocean steamers moored at the elevator. The bins are of steel, but are of square section, 14 x 14 ft.; the sides being stayed by a patented system of construction of the Metcalf Co. The walls of the bins are strengthened by 1¼-in. diagonal tire-rods across the corners, the points of attachment being about 4 ft. 8 ins. from each corner. Each side of the bin at this point is formed by bent plates forming a vertical hollow rib about 5 × 5 ins., through which the tie rods pass and are secured by nuts on each

side. These ribs are finally filled with concrete. The rods are about 3 ft. apart vertically. There are 102 bins (in 17 rows), 70 ft. high, 101 of which are for storage with a capacity of 1,100,000 bushels.

One bin is utilized for a passenger elevator and stairway and ten are subdivided to contain the receiving and shipping legs and to form small bins. The building is 84 × 240 ft. with a foundation of piles capped by a concrete mattress. The gallery for the shipping conveyor extends to the side of the pier, where another gallery extends from it in both directions for 540 ft., making a total length of 1,080 ft., with loading spouts 60 ft. apart. The galleries are 40 ft. above the level of the pier and each contains a 36-in. belt conveyor capable of delivering 15,000 bushels per hour at any spout.

Miscellaneous Facilities.

HARBOR RAILWAY.—A system of railway tracks owned and operated by the Harbor Commission extends along the whole of that part of the waterfront used by shipping; it has about 28 miles of tracks, and is connected with all railway lines so as to provide for direct handling of cars between railways and warehouses or ships. There are spurs to the grain elevators, coal unloading plants, etc., and sidings along the water front. Each of the new piers has four tracks in the middle (two adjacent to each row of sheds), and on some of the piers there is a track between the sheds and the edge of the pier. The tracks have 72-lb. and 80-lb. rails on ties bedded in the concrete foundation of the granite or scoria block paving, as described above, or in the macadamizing of such wharves as are not yet paved. The equipment consists of three large tank engines of the 2-6-2 class, but the engines of the connecting railways operate over the line to some extent. The operation is carried on by the Harbor Commissioners' traffic department.

Where the wharves are at low level and flooded in winter, the two main tracks or running lines extending along the city side of the harbor property have been elevated, partly on a steel viaduct, but mainly on an embankment having concrete retaining walls and abutments and solid-floor steel bridges over streets leading to the water front. The minimum clear headway beneath these bridges is about 12 ft., to permit the passage of heavily loaded wagons.

FLOATING CRANE.—For handling heavy freight (such as boilers, machinery, etc.) there is a floating crane having a lifting capacity of 75 tons at a 54 ft. radius. This is of similar design to the 140-ton crane illustrated in our issue of Aug 29, 1907; the truss boom is pivoted to the bottom of the outer face, and revolves on this in a vertical plane to give the desired reach. This crane has been used also for raising sunken vessels.

FLOATING DOCK.—There are no large dry docks at this port, but the Harbor Commissioners have contracted for the construction of a floating dry-dock having a lifting capacity of 27,000 tons. This dock is to be completed next year, and will be installed in a basin now being prepared at the lower or east end of the harbor in a 36-acre tract of reclaimed land. The dock is being built by Vickers, Sons & Maxim (of London); this firm will also operate the dock, under lease from the Harbor Commissioners, and will establish and operate a ship repair yard in connection with it.

COAL UNLOADING PLANTS.—There are several large plants of this kind operated by companies which import coal in steamers owned or chartered by them. The largest are those of the Dominion Coal Co., which has one at each end of the harbor. The one at the upper end is located on the Bickerdike Pier and has an unloading capacity of 18,000 tons per 10-hour day. Each plant has five towers traveling on a trestle along the pier, so as to be adjusted to the position of the ship's hatches. A hinged boom is lowered to project horizontally over the vessel, and on this runs a hoisting trolley. A self-loading grab bucket of two tons capacity takes the coal from the hold, and is run back to deposit it in a storage bin on the pier; from this it is delivered by gravity through spouts to cars or wagons, or by small trucks to canal boats. Storage for a winter supply is provided also.

ELECTRIC LIGHT.—The piers, wharves, sheds and harbor property in general are lighted by electricity, current for light and power being furnished by the Montreal Light, Heat & Power Co.

CONSTRUCTION AND MAINTENANCE PLANT.—While there is little deposition of silt in the channel or slips and basins, there is a considerable amount of dredging required for enlarging and deepening the harbor. For this work and also for the construction of piers, bulkhead walls, etc. (most of which is done by the Harbor Commissioners) there is an extensive floating plant. This includes three dipper dredges with 7-yd. buckets, a drill boat, five floating derricks, a floating pile driver, concrete mixing plant, six tugs, scows, etc. Repair shops for the maintenance of this equipment are located on the Mackay Pier. Some of the tugs are of heavy construction, being designed for occasional use as ice breakers. It may be noted that the dredging of the ship channel within the limits of the harbor (17 miles) is done partly by the Harbor Commissioners with their own plant, under arrangement with the government.

Freight Handling Facilities.

The piers and sheds of the improved harbor were designed with a view to the handling of cargo by the winches and cargo booms of the steamers (as is common at North American ports), assisted by winches at the sides of the freight sheds. In view of the fact that a special feature of foreign ports is their large equipment of cranes of different kinds, for handling the cargo, the engineers of the Montreal harbor have made an investigation as to the advisability of providing similar equipment and have visited European ports for this purpose. While conditions are not the same on this side of the water, and have not made such equipment necessary, yet it is recognized that its provision will secure important advantages and a beginning has been made by the introduction of some experimental machines. In the discussion of this subject in the annual report of Mr. F. W. Cowie, Chief Engineer of the Harbor Commissioners, for the year 1909, the following statement is made:

> When it is considered that in the Montreal harbor sheds the quantity of actual freight handled annually amounts to over 2,000,000 tons it is apparent that any material saving in the cost of handling freight would immediately show beneficial results to the port.

This statement is worth careful consideration by the engineers and authorities of American ports. However, the absence of freight handling machinery has not prevented the rapid handling of freight. In 1908, the steamer "Mount Royal" (Canadian Pacific Line) discharged 4,250 tons and took on 9,500 tons of general cargo in 53 hours. The annual report in giving these figures, states that at European ports the average time to load and discharge 10,000 tons is 14 days, while at Montreal 13,750 tons were handled in less than three days.

At Montreal the freight handling machinery installed is of two classes: (1) transporter cranes in the upper floors of the sheds, to handle freight between car and shed or between ship and shed; (2) electric elevators for carrying a loaded wagon and its horses between the upper and lower floors of the sheds. Some inclines of temporary construction have been provided for this latter purpose, but not of such a character as to be convenient or economical. The elevator has been mentioned already, and has been so successful that others are to be built.

TRANSPORTER CRANES.—Each of the two cranes now in use is installed on the upper floor of a shed, and travels across it upon a track laid in the concrete floor. At each end of the tower or frame is a cantilever arm, and over these runs a hoisting trolley. The arm on the ship side is 46 ft. long, and that on the shore side is 36 ft.; with the 14-ft. width of the tower the total length of travel for the trolley is 94 ft. The hoisting capacity is two tons. The machine cannot move lengthwise of the shed, but in order to enable the end of the cantilever arm to reach hatches which are not directly under it in its normal position, the tower is made to revolve on the truck frame. In this way, the arm can be swung through a horizontal arc of 60°, or 30° on either side of its normal position. Loads taken from the ship's hold can be run back and deposited in the middle of the shed. The machine can then be run to the other side of the building, and picking up loads in the shed can deposit these in wagons or railway cars on the middle of the pier. In the same way, freight can be handled from cars to the shed, and from the shed to the ship.

Each crane has three motors of 60, 10 and 5 brake HP. for hoisting, traversing the trolley and moving the crane; the speeds of these movements are 328, 317 and 50 ft. per min. respectively. In 20 hours, one machine has handled about 400 tons of freight. It was proposed to have four of these machines for the upper floor of each shed or one for each 125 ft. of front. It is stated that in some foreign ports one crane for each 20 ft. is considered desirable.

The following extract from the report (1908) of Mr. F. W. Cowie, Chief Engineer, explains the conditions existing at European and North American ports in regard to the handling of freight and ships' cargo, and it also refers to the experimental equipment for Montreal:

> METHODS OF HANDLING SHIPS' CARGO.—In connection with the comparative study of the dock systems in Europe and North America, there is nothing so apparent as the different methods of handling cargo. In every British and Continental port a forest of cranes is visible stretching from end to end of the quays. In North America, the system is ships' tackle and hardworked longshoremen. There is one condition which partially explains the difference in the systems. The crews of most of the ships trading to North America are engaged for the round voyage to a North Atlantic port and return. A number of men from the crew of a ship are always available in a North American port for running the ships' winches. A ship, therefore, having ten winches can, with its own crew, working day and night, do the hoisting at no great cost to the ship.
>
> Time, however, is becoming an essential factor in the closely competing shipping business, as consignees insist on claims for damaged goods and as the various competing ports and transporting routes are being judged on their merits as regards speed, economy and condition of freight. Therefore, new methods of handling cargo in Canadian and American ports must be made available. In South America, at the government ports of Rio and Buenos Ayres, which are built after the British practice, cranes of the latest type have been everywhere installed. These ports have facilities for the very rapid unloading and loading of ships. Consequently, they are attractive to shipowners, with the result that the country reaps the benefit with the better transatlantic service.
>
> The Montreal harbor sheds were designed with a view to the North American system of freight handling, where dock cranes are unknown. It was expected that the freight would be landed on both the lower and upper floors of the sheds by ships' tackle, possibly aided by light shed winches. The question of handling the goods between the shore and the upper floors had been left undecided. After a consultation between the Consulting Engineers and the Chief Engineer of the Harbor Commissioners, with Mr. R. C. H. Davison, Consulting Engineer (of London), in 1907, a report was made to the Commissioners with regard to handling the goods to and from the upper stories of the new sheds. Approach for carts by roadways and inclined ramps was cited, with its high cost of construction and low cost of operation, but increased cost of cartage owing to the ramps. A system of elevators at the ends of the sheds which could convey teams with their loaded wagons between the wharf level and the upper stories, was also reported on; this has low capital cost and higher cost of operation. The third method given was a system of fixed transporters working from the upper stories, overhanging railway tracks and wharf, for transporting goods between the upper stories and railway cars or wagons on the wharf level. In view of the high capital cost and the objection to carting on the ramps, combinations of the latter two methods were given as apparently the best system.

The question of the necessity of dock cranes, however, would not down, even although the sheds had not been designed for, or with sufficient strength for the usual type of swinging crane. The manufacturers of very successful coal and ore-handling plants in the United States were consulted, but a suitable design of a crane which would not require extensive changes to the sheds could not be obtained. The transporter system to be used with hinged "jack-knife" overhanging booms, such as used for coal and ore, was also found to be unsatisfactory.

In 1908, the crane makers in England were approached, and very elaborate designs for cranes were furnished, the adoption of the fast running transporter system (for a dock crane) being considered impracticable. After many consultations, a design was proposed which would not require any extensive changes to the sheds, but which had in view a combination dock and shore transporting crane for the sheds. Owing to the number of steel columns in the sheds and to the required length of the transporters, it was out of the question to design inside portable machines which could be moved to different points in the sheds to meet the different ships' hatches.

A final design was made of a transporting crane to run across the shed on steel rails and having a cantilever transporting structure sufficiently long to extend over the ship when working on the harbor side and sufficiently long to load either cart or wagon beyond the two railway tracks when overhanging the shore side of the shed. To overcome the difficulty of reaching the various ships' hatches a turntable was designed for the carriage, so that the whole structure could be slewed to an angle of 30° on each side of the normal, for adjustment to different positions over the ship.

Two renowned crane makers of England (Applebys Limited, of London, and Stothert & Pitt, of Bath) were asked to submit details and prices for electric transporting cranes of the above type, for handling of 2-ton loads. The tenders were received in July, 1908, and after modifications, a contract was given to each of the above firms to furnish a transporter to be ready for the opening of navigation of 1909. If they are successful, four of these machines to each wheel would, it is expected, handle rapidly and economically all the cargoes which should pass through the upper floors of the very excellent type of harbor sheds at Montreal.

One elevator for each shed has also been recommended, so that light packages of dairy produce from the city warehouses could be successfully handled in the upper stories.

It may be remarked that frequently ships come into port with 9,000 tons of cargo. During the unloading, outward cargo to be shipped is also arriving, so that the necessity of facilities for handling freight with despatch is obvious.

Future Developments.

The works projected between 1887 and 1896 were practically completed in 1909, and the total expenditures on harbor improvements up to that time aggregated about $10,000,000. That the new facilities were needed for the commerce of the port is shown by the fact that all the additional berths for ships were in demand and taken before the work was completed, while many applications for accommodation could not be granted. There is therefore still the problem of development to meet both present and prospective requirements. Experience at Montreal has shown that the modern well-equipped accommodation gives a revenue (per linear foot of water front) more than three times that of the older low-level wharves; also that the former pays a return on its cost, while the older works, not so well equipped, are less successful in spite of their lower cost.

In 1908, the Harbor Commissioners made a study of the trade conditions of Canada, and the relations of the port of Montreal to the ocean, inland and coasting commerce of the country. They then called upon the engineers to prepare a scheme covering the following main requirements, but at the same time keeping within reasonable financial limits: (1) accommodation for trade already in sight, which meant that double the present accommodation would be needed at the end of 12 years; (2) wharves and piers suitable for the larger ocean vessels (up to 18,000 tons register) which will trade to Montreal when the 35-ft. ship channel to the sea is completed; (3) improved railway facilities, and a terminal belt line to increase the value and availability of manufacturing sites; (4) utilization of non-productive harbor areas close to the business district; (5) permanent construction and modern equipment; (6) capacity for future extension; (7) intercommunication between all sections of the harbor property; (8) the reduction of the swift current in the channel along the water front below the Mackay Pier (known as the St. Mary's current) so as to permit of lighterage and thus reduce the high charges for cartage of freight from one part of the harbor to another.

In view of these further developments, the President and Chief Engineer of the Harbor Commissioners visited a number of European ports in 1908, and made a report to the Minister of Marine and Fisheries. Following this, the Chief Engineer was directed to prepare plans for a general and comprehensive scheme of improvement. In the meantime, the Commissioners had received the plans for a scheme proposed by an English engineer, Mr. R. C. H. Davison, who had studied the situation at the request of the Commissioners. Both schemes were then submitted to a board of engineers composed as follows: F. W. Cowie, Chief Engineer of the Harbor Commissioners (Chairman); Mr. John Kennedy, Consulting Engineer of the Harbor Commissioners; Mr. G. J. Desbarats, Deputy Minister of Marine and Fisheries; Mr. Arthur St. Laurent, Assistant Deputy Minister of Public Works and Engineer of the proposed Georgian Bay Canal; Mr. Louis Coste, Consulting Engineer for Public Works of Canada; Mr. Ernest Marceau, Superintending Engineer of the Quebec Canals, and Mr. Henry Holgate, Consulting Engineer.

The scheme prepared by this board, in October, 1909, may be summarized as follows: (1) new high-level piers giving about 16,800 lin. ft. of water front, and so arranged as to provide berths for 24 ocean steamers of 600 to 800 ft. in length; (2) new low-level piers giving about 5,800 lin. ft. of water front, the combined area of the high-level and low-level piers being about 74 acres; (3) new freight sheds with aggregate floor area of 1,386,000 sq. ft.; (4) new grain elevator and conveyor system, with 2,000,000 bushels storage capacity (this is elevator No. 2, now being built as described above); (5) additional high-level railway tracks along the water front, aggregating about 22 miles.

The scheme submitted by the Board of Engineers was adopted by the Harbor Commissioners, and plans were prepared for carrying it out during a period of four years. The Commissioners then applied to the government for a loan of $6,000,000 to defray the cost of the improvements and this was granted without opposition. The money is to be provided in three annual payments of $2,000,000, on which the Commissioners will pay 3½% interest. The work undertaken in 1910 (the first year) included the following: (1) a second grain elevator, described already; (2) the elevation of the harbor railway; (3) the reconstruction of the Victoria Pier and raising its steamship berths to the higher level; the pier will have five high-level berths with 35-ft. of water at low-water, and on the inner side of the pier will be a market basin for river vessels.

In regard to the growth in size of steamers, the investigations of the Board showed that during the past 70 years the tonnage of seagoing vessels has increased 8% per year; that is, it has practically doubled every 12 years. During the same period, the maximum tonnage of vessels trading to Montreal has increased from 987 to 14,900 tons, or approximately 5% per year. This gives a steady average for doubling the tonnage of these vessels every 20 years.

How Freight Is Handled at a Railway Transfer Station.—A clerical force of 210, and a warehouse force of 249 are kept busy at the Waverly, N. J., transfer station of the Pennsylvania R. R., where last year over 100,000 cars of freight, in less than solid car lots, were received, and their contents, sorted into solid car lots, sent to hundreds of destinations. The results of their labor was a saving of 11,352 cars in the performance of the business, and an incalculable amount of time to thousands of shippers.

This station is situated between Newark and Elizabeth, N. J. Into it cars are fed from 12 transportation companies, two terminal companies, and the docks of New York City, also freight arising in Jersey City and Newark. During rush seasons as many as 700 cars are taken care of in a day.

As an illustration of the working of the transfer system, suppose a car loaded with freight originated in a small town in New York State destined for 15 other towns throughout the United States. The car would be rushed to Waverly where its contents would be consolidated with other shipments to the same 15 towns, or to another transfer near those that were too small to command a solid car from Waverly. The freight that is handled in this way is called "preference freight," and the trains that carry it run on schedule with the same precision and almost the same speed as passenger trains.

The transfer platforms at Waverly afford standing room for 212 cars. On certain tracks the outbound cars are lined up empty. The loaded inbound cars are ranged on the opposite sides of the platforms and their contents are transferred to about 250 cars which are dispatched directly to 121 different points daily.

Beside each outgoing car there is a number and a box containing little squares of paper bearing the same number. The checkers in charge of unloading are provided with waybills for each piece of freight. They also have a chart showing the positions of the outgoing cars and their numbers, which represent the places they are to be sent. As the articles are removed they are checked off on the waybills. He then turns each piece over to a truckman together with a slip of paper on which the number of the car that is to receive it is written in pencil. The latter, when he has deposited it, takes one of the ballots out of the box. This should bear the same number as the one given to him by the checker and he is required to bring them both back to show that he has made his delivery at the right place. Waybills are made out for the new cars, which are pulled out to make room for others as fast as they are filled.

This is the work that is performed by the warehouse force, but the clerical end of the business is far more complicated. Besides the waybills, of which 3,500 are sometimes made in a day by a force of 52 clerks, there is the accounting to be done. Division of earnings and settlements must be made with 15 outside companies. The method of keeping track of what the company owes to, and is owed by the other companies for handling freight, is similar to that employed in a clearing house. In addition to the warehouse force, which is occupied directly with the transfer of freight, eight distinct departments are required to look after the details of the transference. There are a Pennsylvania Railroad Accounting Department, a Union Line Accounting Department, separate departments for east and west bound waybills and car records, a Tracing Department and a Transfer Record Department.

The Waverly Transfer was opened in September, 1904. At first it was planned to handle only the freight from the New York, New Haven & Hartford and the Long Island R. R.s. Its capacity was 96 cars. After six weeks it became necessary to employ day and night shifts to keep up with the business. The station was soon enlarged to accommodate 200 cars and later its capacity was increased to 212. Illustrative of the transfer's rapid growth is the fact that the tonnage for less than carload lots has increased nearly twofold from 1905 to 1910, and the total tonnage has more than doubled in the same period. The number of inbound and outbound cars has grown in like proportion. The difference between the number of inbound and the number of outbound cars represents the saving made by handling the freight in solid car lots. This difference amounted to 10,872 cars in 1909 and 11,352 in 1910.

That greater economy in the matter of car mileage is being generally practiced by the railroads is indicated by the increase in average load per car received at the transfer, from 5.67 tons in 1905 to 6.33 tons in 1910. Of course these figures also bear some relation to increased business, which makes it possible to load more heavily. From the beginning there has been a great saving in car mileage at the transfer, the outgoing cars carrying an average load of 6.44 tons in 1905 and 7.42 tons in 1910. (From a statement issued by the Pennsylvania R. R. Co.)

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A Wrong Way of Improving Municipal Government.

Under the title "Municipal Ignorance, Waste and Graft" the "Wall Street Journal" of Oct. 31 indicts the government of New York City for the increased tax rate of the last few years. The only data it presents are the New York rates and the average rates of "other cities," both for the past six years. The data and deduction to which we refer are as follows:

How excessive taxation has become, as compared with the levies in other cities, is shown by the following percentage of our tax rate to the average rate for other cities during the past six years:

Year.	New York tax rate.	Rate of other cities.	Per cent.
1910.....	$17.5790	$15.96	110.14
1909.....	16.7804	15.82	106.07
1908.....	16.1407	16.12	100.13
1907.....	14.8499	16.32	90.99
1906.....	14.7890	16.16	91.57
1905.....	14.9051	16.16	92.29

Had our government been managed no better than other municipalities, since 1905 the tax rate would now be about $2.76 less than it actually is, and the saving to the people of New York would amount to $20,470,000. This saving is equivalent to $4.29 per capita, or about $19.75 per family. The voter who imagines that, because he does not own real estate, he avoids this additional tax, could not be more greatly mistaken; for while he may not pay it directly, he does pay it none the less actually in higher rents to his landlord, or higher prices for food, clothing and fuel.

Let the voter once be taught that it costs himself and his family about $20.00 annually to keep corrupt officials in office, and we shall have made an all-important first step to good government.

Quite regardless of our opinion of the character of the government of New York City, we submit that the figures cited, without supporting and explanatory statements, have little significance. A mere increase in a city tax rate is no proof of—anything, except that the rate has increased. The significant thing is the causes or objects of the increase and the returns received from increased expenditures. Likewise, the comparison of the tax rate in two cities—much more so in a given city as contrasted with an indefinite number of unnamed cities—means nothing, unless accompanied by comprehensive statements of what is attempted and achieved by the municipalities whose rates are contrasted.

Moreover, if the table given by our contemporary proves that the "other cities" were better governed than New York in the last three of the six years named because their average tax rate was lower than that of New York, then by the same reasoning conversely applied New York City was better governed in substantially the same measure than the other cities in 1905-6-7.

Our contemporary seems to have fallen into the all-too common habit of comparing statistics which are not properly comparable. We would not comment on the matter were it not for the fact that it illustrates anew the desirability of reducing municipal statistics to a readily comparable basis, so far as that is feasible. This involves the evolution of some method of correlating expenditures with results, and expressing the latter in terms of quality as well as of quantity—which is a problem for engineers and statisticians, cooperating with those who are competent to weigh the value of services rendered in various fields of municipal endeavor.

A Federal Judge on Municipal Ownership and on Water Rate Regulation by Public Service Commissions.

A declaration in favor of municipal ownership to prevent various controversies with water companies and failing that a bold declaration for the regulation of water rates by public utility commissions instead of through the law courts was made by a federal judge in an Iowa district court in an opinion in a Des Moines water-works case, reported elsewhere in this issue.

We have long favored municipal ownership as a general proposition, its adoption in a specific case to depend upon local questions of expediency. We have also taken a stand more than once for the regulation of the rates of water and other like companies by state commissions created for that purpose, rather than by municipalities or by the courts—the place where, sooner or later, attempts at direct municipal regulation are likely to come.

In the present Des Moines case the court states that the litigation was begun more than three years before the decision was filed. It adds that before a final decision is reached in this and like cases four or five years are almost sure to elapse. We may add that in the famous San Francisco water-rate litigation the decision of the lowest federal court on rates established in 1903, 1904 and 1905 has just been announced. Presumably an appeal will carry the final decision to a point at least ten years beyond the date of the earliest rate ordinance in litigation.

The public-utility commissions act much more rapidly than the law courts, since they deal with nothing but questions relating to the rates charged and services rendered by public-service corporations. Moreover, these commissions soon gather a veritable storehouse of data more or less pertinent to all the cases which come before them, while the commissioners and their permanent staff of engineers and other experts are constantly adding to their experience and judicial faculty.

The San Francisco litigation over water rates has been well nigh constant for many years, as might be expected under a state constitution which compels local authorities to establish yearly the rates to be charged by private water companies. The folly of such a provision was urged in our issue of May 27, 1909.

Water rate litigation at Des Moines has not been so continuous as at San Francisco, we judge, since Iowa cities are merely authorized to regulate rates, but, unlike California municipalities, are not compelled to do so once a year. Yet there has been litigation a plenty at Des Moines. Almost twenty years ago (Feb. 27, 1892) in an editorial on "The Regulation of Private Water Rates," we discussed a controversy over water rates then prevailing in Des Moines. Later, the controversy went into the courts, and during the ensuing twenty years Des Moines has been engaged in water or gas rate litigation a considerable part of the time.

In 1892, and for some years after, the Des Moines litigation hinged largely on one of those vague blanket clauses common to the golden age of franchise promotion. This clause (franchise of May 1, 1871) provided that the rates charged by the Des Moines Water Co. should be "no more than the average price paid in other cities of the United States having efficient water-works." Even in the early nineties this ridiculous franchise provision proved to be of no force and the rates were adjudicated on the basis of reasonableness.

The present litigation at Des Moines also hinges on the reasonableness of the rates. Judge McPherson goes beyond this, in an aside, and questions the reasonableness or wisdom of burdening the courts with rate litigation in Iowa when public-utility commissions in other states are handling rate questions in an eminently satisfactory manner. He pointedly suggests that the time has come for Iowa to establish a public-utility commission. Undoubtedly it has.

Since in this discussion we have linked water rate litigation in Iowa and California it is pertinent to add that, if we are correctly informed, one of the 23 constitutional amendments adopted by popular vote in California last month (October, 1911) will take rate control away from local authorities and vest it in the State Railroad Commission, which will control all public-utility companies operating in California.

Whether this be true or not it is high time for Iowa to join the other progressive states of the Union by creating a commission with full power, adequate staff and ample funds to settle controversies over not only water and other like rates but also to control public-utility companies in other particulars.

The law courts are altogether too much overburdened with other duties to deal promptly with rate litigation, and even if they had time for such cases they are no more fitted to deal with these than with some other technical questions which come before them—such as many patent cases, for instance. When a call for relief and reform comes from the courts themselves it should certainly be heeded.

Why Public Utility Commissions are Waxing Strong; With Illustrations from New Jersey.

One reason why some short-sighted public-service companies oppose the creation of state public-service commissions is because they know full well that once such commissions are established they will no longer be able to evade contract requirements or enforce rates and regulations without contract or other warrant by simply falling back on legal technicalities or lame excuses. Moreover, these short-sighted private corporations know full well that once an honest commission is established, even though its powers be unduly small, it will gain public support with every corporation injustice it wipes out and that this support will increase at such a rate that its powers and funds will be increased at every session of the legislature.

Two years or so ago the New Jersey legislature passed a public-utility commission bill, after years of agitation, but a bill that had been so weakened by legislators more anxious to please the corporations than the public that the public-utility lobby did not take the trouble to oppose the bill. We remarked at the time (Eng. News, May 26, 1910) that weak as the bill was it would prove to be not only a step in the right direction but would be followed by other and longer steps. Our prediction speedily proved true, for the legislature of 1911 gave the commission greatly enlarged powers.

Already the people of New Jersey are benefiting from these enlarged powers. Municipal councils that had been struggling hopelessly for what they considered fair terms in contract renewals with utility companies suddenly found those companies willing to grant what they had previously declared to be impracticable or ruinous concessions. Still other municipalities, and in some cases individuals, have secured orders from the Commission for the fulfilment of contract requirements or the cessation of abuses, or for rendering some service required by public policy and general charter obligations, but denied for one reason or another.

So far as we have learned, the New Jersey Commission has not yet made any rulings of such far-reaching nature and universal interest as

have the Wisconsin and New York commissions, but time and perhaps experience are required for that. Moreover, it remains to be seen whether the holdover Commission created as a result of the first and emasculated legislation has the backbone or disposition necessary to stand up against the big public-utility companies of the state—in large issues; the Commission has already done so in small matters.

Some of the relatively small but by no means unimportant cases decided by the Commission may be cited as promises of greater things, not to be expected until more time has been available for hearings and deliberation. We briefly abstract three decisions, as follows:

Alleged lack of funds for water main extensions in the borough of Oaklyn, N. J., has been held by the Board of Public Utility Commissioners of New Jersey to be no excuse for not fulfilling a contract made by the United Water Co., of Haddon Heights, with the borough named. The contract was made in 1909 and called for water mains and 35 hydrants within eight months from its date. The Board has ordered mains of stipulated lengths to be laid on certain named streets by July 1, 1912.

Water meter rentals and separate and extra minimum yearly charges for water supplied through a single meter to two extra cottages on the same lot and in the same ownership were ruled against on complaint of Henry C. Chalmers, of Holly Beach City, against the Wildwood Water Works Co. This company had established a minimum rate for metered water of $8 per year and a meter rental of $1.50 per year additional. The owner of a seven-room cottage, or a 40 × 100-ft. cottage, erected two four-room cottages at the rear of the lot and extended his service pipe, from the house side of the meter, to supply the new houses. The commission blames the man for having done this without notifying the company, but rules against the extra charge for the cottages and for meter rental, holding the latter to be a virtual increase in the minimum charge allowed by the company's franchise. At the same time, the Commission announces that if in the future the municipal contract is amended so as to authorize graded minimum charges for premises of different character it will, if called on, consider any arising case on its merits. It also recognizes the fact that should the supplying of the additional cottages through one service require a larger service and meter there might be ground for an increased minimum rate.

The stopping of trains at Asbury Park on Sundays by the Pennsylvania and other railroads has been ordered, notwithstanding an agreement under which the Ocean Grove Camp Meeting Association gave certain property to the railroad on agreement that trains should not be stopped Sundays within certain limits in or adjacent to the camp-meeting grounds, under forfeiture of the land to the association. This agreement and the resulting practice has worked great inconvenience to an increasing number of residents in and visitors to Asbury Park, who have been thus compelled to use a small and inconvenient station at North Asbury Park on Sundays. It may be added that the Asbury Park station, at which trains must stop hereafter, is not on the land transferred to the railroad.

We think all will agree that each decision like the foregoing, made in various parts of any state, adds to the unlikeliness that a public-utility commission once established will ever be abolished, and increases the likelihood that its powers will be enlarged.

It takes no high degree of disinterested intelligence to see that the corporations as well as the municipalities and individuals are alike benefited by having controversial points adjudicated by a well-constituted state commission, free from local influences and powerful enough and sufficiently well-informed, through its members and experts, to settle differences with even-handed justice to all concerned.

Transfer of Engineering News Book Department.

The Engineering News Book Department has been transferred to the McGraw-Hill Book Co., of which Mr. John A. Hill is President and that company will hereafter handle all business in connection with the publication and sale of books heretofore transacted by the Book Department of Engineering News. All orders for the purchase of books and all correspondence regarding their publication which have heretofore been sent to the Engineering News Publishing Co. should hereafter be sent direct to the McGraw-Hill Book Co., 239 West 39th St., New York City.

Organization, System, and Efficiency in Manufacturing Industries.

We wonder whether readers of the technical press are not a little weary of papers on "efficiency engineering." During the past year, ever since Mr. Brandeis gave "scientific management" its great boom of publicity by offering to save a million dollars a day for American railways by introducing this magic method, papers on scientific management have seemed to spring from the ground. A fair-sized library of treatises on the subject has been produced and at least two well-known periodicals have constituted themselves "organs" of this new movement. Certainly the apostles of this new departure are adepts in the art of publicity.

The editors of Engineering News deserve well of its readers, not only because of the articles which we select and print but also because of the articles which we save our readers from. We deserve the especial gratitude of our readers, if they only knew it, because of the articles on "scientific management" which we might have published and did not!

We say this, moreover, with full recognition of the importance of the subject, and of the stimulus to better industrial organizations which the recent carnival of publicity has induced. Efficient organization, with all that it involves, is unquestionably one of the big problems of the present day. Really reliable information on this subject from men who know is very well worth while; but a very large proportion of the literature on "scientific management" which is being poured forth needs to be read with much caution; and much of it is worse than worthless, because it is misleading.

As we have not surfeited our readers during the past year with a multiplicity of articles on this subject, we are in position to emphasize the great importance and value of the paper which we print in this issue entitled "The Economic Administration of Industrial Establishments," by Mr. John Calder, M. Am. Soc. M. E., general manager of the Remington Typewriter Works at Ilion, N. Y.

The main part of Mr. Calder's paper is devoted to the general subject of organization as it affects all sorts of industries. It impresses us as the best and broadest and fairest discussion of this subject that has anywhere appeared. What Mr. Calder has to say concerning the importance to business success of a harmonious, loyal and efficient organization is not only worth reading but worth reading over and over.

"The primary object of organization," says Mr. Calder, "is to bring brainy men together for work and action. A wise organization seeks and encourages men of ambition. Unless the leader sees and plans for an opportunity for a useful career, not only for himself but for his staff, he cannot reach the highest success."

We wish these words and similar utterances of Mr. Calder could be brought forcibly home to the comprehension of every owner of a mill or mine, shop or store, to every officer and director in our modern industrial combinations.

The first essential of success in any business enterprise which has grown beyond the capacity of one man to direct in every detail is that the leaders of the enterprise shall be harmonious and earnest in working together for a common end. This is as true of the great industrial aggregations as of the concerns of smaller size.

A good many of the financiers who have come into control of our great industrial combinations since the era of trust organization ten years ago have failed to appreciate this. They have considered managers and superintendents and engineers, to say nothing of the rank and file of employees, as about on the same plane with raw materials, that is to say, they [illegible] to be bought in the market at the lowest pric[illegible] treated like any other machine, solely on th[illegible]sis of what they could produce. There are [illegible]cerns which have changed managers half a d[illegible] times in the past decade. Perhaps we should [illegible]y there were concerns, for such frequent swe[illegible] changes in the responsible heads of any bu[illegible]ss enterprise almost invariably result in its f[illegible]re. The internal history of many a defun[illegible]usiness is a story of internal dissensions, of [illegible]mpetence in management; or of men really [illegible]mpetent and able, handicapped by being set at work to make bricks without straw.

Mr. Calder states as one of the first essentials of success in any business, a strong resourceful leader; but he names as equally essential "a carefully selected, well-trained, loyal and enthusiastic staff." It would be difficult to express more in fewer words.

We call especial attention to this matter of organization and leadership because the current propaganda on "scientific management" has placed the emphasis so much on "system" that the human side of the organization is in danger of being overlooked. Mr. Calder performs a useful service in calling attention to the fact that any and all systems are unimportant compared with having a group of strong men at the head of an enterprise working in harmony to bring it success.

Of course system is necessary in a concern of any considerable size; but it is not so far out of the way to call it a necessary evil. Mr. Calder gives an admirable rule when he suggests that any system is worth only what it can earn, no more. There is a tendency at the present day to make a fetich of "system," to assume that a big business is well managed if everything is regulated by a certain system. There are offices and works where many thousands of dollars are being spent annually keeping up an elaborate system of records, checks, vouchers, indexes and what not, and which when accumulated are never put to any beneficial use at all proportionate to their cost.

And the direct outlay upon this mass of red tape is less injurious to the prosperity of the concern than the palsying and deadening effect of a cast-iron standardization system, which leaves no play for individual initiative and enthusiasm.

There is a too-common impression abroad that this "scientific management" is a sort of mechanical method which once introduced into an establishment enables it thereafter to run with clockwork precision, creating efficiency as certainly as an automatic loom weaves cloth.

Never was there a more fundamental error. A live business concern is not a machine. It is a living organism, a composite of the men who join in its activities. Make it into a machine by transforming the men who control and direct it into clockwork automatons and its source of life is destroyed, so that its defeat in the struggle of competition is certain.

We believe those who have most carefully and impartially studied the work of some of the "systematizing specialists" will agree as to the need for the cautions concerning the abuse of "system" which Mr. Calder expresses. On the other hand, he is fair and judicial in giving large credit to Mr. Taylor and others who are working in the same field for stimulating progress toward greater efficiency in industrial operations.

And this progress is really in the nature of an evolution. One may trace its beginning, as Mr. Calder does, far back to the early years of the last century when the industrial era was just beginning. One may trace its progress a quarter century or more ago in such movements for standardization as made the name of Whitworth famous in England and that of Sellers famous in this country. The present so-called "scientific management" is only another step forward in the progress of industrial development. It is built on the foundation of what has gone before; and is largely made possible in many of its details by the development, mechanical and social, which preceded it.

Finally, an additional word of emphasis is

needed concerning the fact that the kind of system and amount of system, desirable in various industries, varies enormously. Mr. Calder in the concluding portion of his paper describes the organization of the great works of which he is the manager, devoted to typewriter manufacture. This portion of the paper is likewise exceedingly valuable; but this does not mean that the organization there described should be copied in any other works, even one engaged in a similar class of manufacture. Every business has its own special problems; and the best organization for a business is the one which best fits its especial needs. We suspect that a good deal of harm has been done by some of the professional systematizers through trying to make one pet scheme fit diverse conditions.

LETTERS TO THE EDITOR.

Automobiles as Road Destroyers—Toll Roads to Place the Burden of Road Maintenance Where It Belongs.

Sir: Two of the principal problems confronting the officials responsible for the building and maintenance of our public road system are first the discovery of a road surface which will withstand the wear of modern traffic and second a just distribution of the burden of expense of maintaining good roads after they are built.

The discovery of a satisfactory road surface is problematical, but not impossible, and its solution will simplify the second problem. Until this surfacing material is discovered, the problem of maintenance is very serious, but also not impossible.

Of all false sayings, none is more false than that the automobile has given us good roads. The fact is that the automobile has destroyed most of the good roads which existed before its advent and is rapidly destroying the newer roads, which have been built at enormous expense by the taxpayers for the benefit of the community.

The automobile manufacturers and associations, assisted by those interested in the business of road building, have inveigled the taxpayers into spending a vast amount of money for roads which are no sooner finished than these same interests begin to destroy them, while still crying for more.

Good roads are necessary and the money for building them should not be withheld by the taxpayers, provided the public in general is benefited. Automobiles are also good things and their manufacturers and owners ought to be willing to pay for the damage they do to state property. If an eccentric individual should claim that he found pleasure and benefit to himself by digging up the surface of a newly finished road with a pick, he would be restrained and fined, if not imprisoned, to punish him for the damage he had done. The general public would see no pleasure in such an occupation and manufacturers of picks, would see no new demand for their product. It is an open question, however, which would do the greater harm in the same length of time on a given stretch of road, the man with the pick or his neighbor in a heavy high power automobile.

All vehicles traveling over a road produce a certain amount of wear. If the taxpayers supply the money to build the roads, it would seem just that those using the roads should pay for their maintenance.

The suggestion to establish toll stations to provide funds for road maintenance may seem a step backward, but it is difficult to conceive any other method which would gauge as accurately to just what extent each individual user of roads was responsible for their condition. Formerly it was the heavy commercial vehicles which wore out the roads, the damage done by pleasure vehicles being almost a negligible quantity. Now the situation is reversed and if pleasure vehicles were taxed in proportion to the damage they do, commerce would be relieved of a large part of the burden it now bears for road maintenance.

A general tax on any class of vehicles would be unjust as it is only while a vehicle is in use on a road that it does any harm. The amount of toll collected would depend on the amount of damage which the average vehicle of a class did to a road while using it.

In villages where most of the street traffic is local, a general road tax would seem best, but for the country roads in general a system of toll stations operated by the county, with state supervision over those roads constructed by the state, would collect most justly the money required for the maintenance of the roads.

If the automobile interests desire to make good their boasts that they are giving good roads to the country, they would find little difficulty in having the toll rates raised on automobiles to any extent over that necessary for repair work, the excess money collected to be used for the carrying out of some of the extravagant schemes in road construction which they are at present trying to foist on the taxpayers.

Yours very truly,
Chas. S. Wray.

Highland Mills, N. Y., Oct. 30, 1911.

[The objections to a toll road system are not alone the tax involved in the amount of the tolls; but the nuisance and actual expense involved in the stoppage of traffic at toll-gates. Public sentiment is unquestionably in favor of free public highways. England has solved the problem of making automobiles pay for the damage done to highways by assessing a heavy annual tax on every machine, proportioned according to its horsepower. The fund thus collected is distributed to local road authorities for use in highway improvement and maintenance. The rates were published in Engineering News of Oct. 13, 1910 (p. 401), and vary from $10.25 per annum for a car of not over 6½ HP. to $202.70 per annum for cars over 60 HP.

In Massachusetts the State automobile license fund is used for road work and brought a net income to the state in 1910 of $303,000. The total amount spent on maintenance of state roads was about $515,000, so that when allowance is made for damage done to the roads by other vehicles it may be claimed that Massachusetts automobiles with an average annual tax of about $10 per car are paying for at least the bulk of the damage they do to the roads.—Ed.]

The Height of Chimneys As Defined by the Chicago Building Ordinance.

Sir: A section of the Chicago Building Ordinance reads as follows:

577. HEIGHT OF CHIMNEYS ABOVE ROOF. (a) The height of all chimneys and flues of stoves used for domestic purposes or open fire places shall be not less than 5 ft. higher than the highest point of the roof of the building of which they are a part.

(b) The height of all chimneys and flues above the highest portion of the roof of which they are a part, where such chimneys or flues are used for other than domestic purposes or for open fire places, shall be determined by dividing the greatest diameter in inches by 4, and the quotient thereby obtained in terms of feet, with 5 ft. added, shall be the minimum height from the tops of such chimneys and flues above the highest portion of roof of the building. In no case shall the height

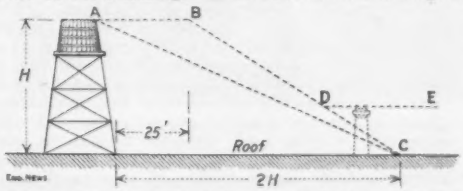


Diagram Illustrating Chimney Heights; Chicago Building Ordinance.

of any chimney or flue be less than 5 ft. above the roof of the building of which it is a part.

(c) The sum of the horizontal distance of any wood tank, pent house or roof house, on the same building of which any chimney shall be a part, and the vertical distance of top of such wood tank, pent house, or roof house, on the same building to a horizontal plane passed through the top of the chimney shall not be less than 1½ times the required height of the top of the chimney above the roof. The tops of chimneys within a radius of 25 ft. of any wood tank, pent house, or roof house, on the same building on which such chimney shall be a part shall be at least as high as the top of said wood tank, pent house, or roof house. The tops of chimneys on ridge roofs shall be not less than 3 ft. above the ridge.

It is hoped some of your readers may be able to interpret the wonderful English in (c). The Deputy Commissioner of Buildings declines to make a decision, so that up to the present time the height of a chimney is a matter left to his judgment.

The writer has presented to him a solution shown by the accompanying sketch. A chimney with top touching the line AC satisfies the conditions in the first statement of (c). A chimney reaching the line AB satisfies the conditions fixed in the second statement. It would be ridiculous to have a chimney 25 ft. from the tank touch line AB, and a chimney 26 ft. away touch the line AC; so the chimney heights should be governed by the line ABC. Section 577 fixes minimum heights for all chimneys and thus is obtained the line DE.

The writer claims, that, while the section is very badly written, it is capable of interpretation and that the line ABDE fixes chimney heights in Chicago. Ernest McCullough.

Chicago, Ill., Oct. 9, 1911.

Against Federal Control of Non-Navigable Streams.

Sir: I suppose it is true that the clause in the United States Constitution giving the Federal Government control over all navigable streams could be stretched so as to cover control of works on tributary non-navigable streams, as suggested by Mr. D. M. Andrews, M. Am. Soc. C. E., in your current issue, just as the Interstate Commerce clause has been made to form the constitutional foundation for a pure food and drug law or a proposed child labor law. But has it ever occurred to your correspondent that such continued straining of the Constitution beyond the elastic limit is bound to cause a permanent set and eventually complete rupture of the poor old document? The means provided for amendment are purposely cumbersome, but were it not better to invoke them rather than to make the document in its present shape say something which its illustrious authors never intended it to say, nor, probably, ever dreamed of its saying? Or is, indeed, such Federal control even desirable?

Further, as to your suggestion in regard to interstate dams, and the argument which you draw therefrom, cannot this argument be pushed logically a little further? Take the case of the Colorado River and the Imperial Valley so much discussed a few years ago. In this instance, the breach leading to the disaster occurred in Mexico, but the greater part of the damage was inflicted upon the United States. Or suppose a dam on the Rio Grande at any point along the international boundary. Evidently, neither Government would have complete control. There should therefore, according to your argument, as I understand it, be erected some Power superior to either Government with control over all water powers in both countries. Similar conditions might easily occur near Sault Ste. Marie, Detroit, or at some other point or points along the Canadian boundary. Evidently, therefore, Canadian streams should be included under this supra-national control; but, as Canada is a possession of His Britannic Majesty, the control should be extended also over Great Britain, Australia, India, Egypt and South Africa. In short, by a similar chain of reasoning, we should include the whole earth under our supra-National board, excepting for a few outlying islands like Cuba or Haiti, all of which is, of course, absurd. A dam or other controlling works on the Rio Grande or at the "Soo" would be provided for and protected by international agreement. Similarly, should not a dam on a non-navigable interstate stream be provided for and protected by interstate agreement?

But, to leave the lawyer's point of view: would Federal control be advisable? Has the United States Government made the best possible use of the powers she already has over bodies of water? Has not the "log-rolling" method almost universally prevailed in the past in the drawing up of "River and Harbor" bills, even to the point, sometimes, of national scandal? Would the Government probably do any better if it should assume enlarged powers, as suggested? Suppose that some bureau were given ample authority to deal with the subject without Congressional interference. What one is in a position to do so except at enormous—one may almost say—prohibitive—expense? Either the War Department or the Geological Survey would seem to be the logical candidate for the responsibility; but both are already overburdened with their present duties, and while performing admirably those tasks, could hardly undertake such added work, vastly important as it is, scattered over enormous distances and often in well-nigh inaccessible localities.

On the other hand, many of the states have regular engineering departments (and all should have) which, as one might say, are on the ground and which could assume control over dams and similar works much more economically and with much better understanding of local conditions than could the United States Government.

We all agree, since the Austin and Hatfield disasters, that governmental control over dams should be much more rigid than at present, but it seems to me that the most logical and best method to reach the end desired is by the "good,

old way" of State control rather than by laying violent hands on our vital organic laws by reading into the Federal Constitution a power which our fathers never intended should reside there. The chief objection to State control is, of course, the diversity of the laws in the different states; but I am inclined to believe that the next few years will see the different states getting together and making their statutes much more nearly uniform than they are at present. This would be a splendid subject for the "House of Governors" to "legislate" upon.

Yours truly,

S. D. Newton, Assoc. M. Am. Soc. C. E.
613 Spring St., Jamestown, N. Y., Oct. 23, 1911.

[Control of interstate streams by interstate agreement sounds well; but actual experience has shown that attempts in this direction result in nothing but fruitless litigation. The proposition to have New York City take water from the Ten Mile River to meet a dire emergency, was met in the state of Connecticut by the most strenuous opposition, notwithstanding the fact that the actual damage which would have been caused to a few mill owners would have been so small as to be hardly estimable, and New York was ready and anxious to pay liberal compensation.

Such conditions are not likely to be changed so long as interstate relations are left to be fought out in the courts. To control the International waters on our northern boundary a wiser plan has been adopted and an International Commission on which the engineering profession is well represented has charge of the matter. When the states are wise enough to establish really high-class engineering departments, the way will be open for the equitable adjustment of control over interstate waters, by joint action of engineers representing the states interested.—Ed.]

Water-Works Valuation and Rate Decision, Des Moines Water Co., Des Moines, Ia.

Besides many other comments of interest some significant remarks on the difficulties involved in municipal attempts to regulate water rates, on the necessary slowness of the courts in dealing with rate cases, on municipal ownership, and on public service commissions as better agents than the courts in settling water rate controversies were recently made by a federal judge in the Des Moines water rate opinion reported elsewhere in this issue. Many of the remarks apply with equal force to other public utilities besides water-works.

One way out of the difficulty, the judge declared in the introduction to his decision, is municipal ownership. Another, and this he apparently would heartily welcome, pending municipal ownership, is rate regulation by public utility commissions. After expressing wonder that no such commission has been created by the Iowa legislature the judge proceeds with his discussion of the case in hand—and one can almost hear him utter a deep sigh of weariness as, after contemplating the prevention of rate litigation by municipal ownership or by public utility commission control, he turns to one of the many tasks still before the courts.

The particular case in question is an outcome of an ordinance passed a number of years ago by the city council of Des Moines, Ia., fixing the rates to be charged by the Des Moines Water Co. The company brought suit to have the ordinance set aside on the ground that the rates were unreasonable. Since, as the judge declares in his opinion, if the court heard all such cases in person, it could do nothing else, the taking of testimony and the determination of both facts and of law was referred to a master in chancery. The decision under consideration overrules exceptions made to the master's report by both the city and the company and confirms the findings of the master.

These findings are not repeated in the decision, except as to some of the controverted points. It appears that the master fixed the valuation of the property of the Des Moines Water Co., for rate-making purposes, at approximately $1,850,000, and held that since the rates in question would not yield 8% on this valuation the ordinance is void. The court also upheld the master's allowance for going value. What the master decided and what the court rules on the highly contested question of including in the value of the plant the extra cost that would have resulted had 38 miles of pipe been laid after instead of before the corresponding streets were paved is not made clear by the opinion. The plain inference is that the pavement question was ignored, since the judge declares that the earning power of the plant is unchanged by the presence or absence of pavement.

The opinion which we have outlined introductory to reprinting the greater part of it was filed on Sept. 16, 1911, by Mr. Smith McPherson, Judge of the U. S. Circuit Court for the Southern District of Iowa, Central Divison.

After stating that the ordinance in question was passed more than three years before the date of the opinion, Judge McPherson says:

Evils of Existing Situation.

This case illustrates the evils in connection with the fixing of rates by municipalities to govern public utility corporations. Neither party is properly chargeable with any dereliction; and yet the fact remains that by the time this case is decided by an appellate court, at least four years will have elapsed from the passage of the ordinance until the matter is put at rest by the courts.

Cities May Purchase As Remedy.

In the face of these long delays and the tremendous expense attending the hearings, it is apparent that some other method must be devised to determine the matters as to some of these public utilities. One of these schemes has been validated by the decision of the Supreme Court of Iowa in the case Halsey vs. City of Belle Plaine, 128 Iowa, 467 (104 N. W. Rep. 494), in which the law is now said to be that cities can constitutionally go in debt at least three times the amount that they could incur until that case was decided, in the year 1905. [The constitutional limitation of bonded indebtedness to 5% of the property valuation was held to mean actual rather than assessed value.—Ed.]

The Iowa Legislature has enacted a statute, Chap. 45, Laws of the 33d General Assembly (1909), which provides for the condemnation, and taking over of water-works, and the city, as a city, becomes the owner of such plants. The value thereof is ascertained by three district judges, designated by the Supreme Court of the state, and the owners of the plant are compelled to part with the ownership upon receiving the value thereof from the city. Under the construction of the Iowa constitution, above referred to, the city can go into debt to raise the money and become the owner. The city can borrow the money at a less rate of interest than can a private corporation. When the city becomes the owner of the plant, all these litigations will be at an end. It may be that the people will not be better served, but the wranglings and disputes will be between the city officers and the people. If proper service is not given, the people can only complain of their own officers. It may be that property owners will pay more for their water, including their share of interest, than they would pay to a private corporation. But this will be largely compensated, when counting the expenses of litigation, and the unending quarrels that follow the present method of having private corporations to operate water-works plants. It may be that the water-works company will not be able to receive all of their investments back. But, considering the limitation on their franchises, and the difficulties now encountered to get money with which to build water-works plants, it is better that they charge off their losses and bring present methods to a conclusion.

Public Utilities Commission.

The present expensive chaos should be brought to an end. *It is known by all informed men that city councils necessarily adopt rates with but little or no investigations as to what rates ought to be fixed. The result is that we have ordinances fixing rates based upon but little intelligent effort for the ascertainment of the facts.* Some of the states, like New York, Massachusetts and Wisconsin, have state commissions of competent men, who give public hearings, and who do nothing behind doors, nor in secrecy; *a commission with no member interested as a taxpayer of the city and with no member subject to influences other than the ascertainment of the truth and the facts. Rates are thus fixed with which most fair-minded people are ready to acquiesce. It is strange that we have no such legislation, and no such commissions in Iowa.*

Either of the foregoing [illegible] would largely cure present evils.

City Councils May Regulate Rates.

But, the existing situation [illegible] such that city councils have the lawful right [illegible] rates, provided, always, that such rate [illegible] reasonable. And when the rate is thus fixed [illegible] city council, the water-works corporation [illegible] the right to challenge such rates by a suit [illegible] equity in the courts. Such is this case. *This case was referred to a competent and efficient, and [illegible] master in chancery. He has found that the [illegible] fixed by the city council of Des Moines are not reasonable rates. Exceptions to this report have been filed, and are now to be decided by this court.*

There are some matters of law now no longer the subject of serious debate.

One of these propositions is that the rates thus fixed by a city council are presumptively correct, and the water-works corporation challenging the same, must overcome such presumption, and must affirmatively show by a fair preponderance of the testimony, that the rates thus fixed are not sufficiently remunerative.

Value, Not Cost of Plant the Question.

Another proposition is, that in this court, in arriving at a conclusion as to what rates are lawful, we are to have ascertained the value of the plant. *The question is not what it cost,* although such evidence is admissible as having a bearing. The question is not what the plant some day may be worth, although evidence with reference thereto may be considered as having a bearing. *The question is: What is the value of the plant to-day?* There must be a reasonable rate of interest or dividends allowed on the value of the plant.

What a plant costs originally is not the measure of value that courts must look to, to determine the validity or invalidity of rates. The value of stocks and bonds is no test, for obvious reasons, and mere theorists only, at the present day, insist upon such as the valuation. Practical men know that it is not the test. **There can be no true test other than the physical valuation, and to such physical valuation, there may be added certain other items.**—[Heavy-faced letters ours.—Ed.]

Paving Over Mains.

The Master has made one finding that has been the subject of more discussion, perhaps, than any other item in the case. He finds that there are practically 38 miles of pipes that were laid in the streets at a time when the streets had not been paved, but that since the laying of those 38 miles of pipe, the streets have been paved. To reproduce the same, would require an expenditure of from $108,896, as admitted by the city, to $216,000, as claimed by the water-works company, more than would be necessary to expend to lay such pipes in unpaved streets. Whatever the true sum is, the water-works company claims such sum to be a part of the value of the plant. This proposition the city denies. But it is not pivotal in this case. Much can be said on each side of the question. This case seems to have been tried before the Master, by both parties, upon the reproduction theory. That is to say, what this plant would cost if it were blotted out of existence, and the city, or some other company, were to undertake to reproduce the plant. In such an event, as of course, the pipes must be laid under these 38 miles of paved streets at this additional cost. Looking at the question in that light, the question is: What would it cost to-day to reproduce the plant, and from which, to get at the value of the present plant, there would be deducted the value of depreciation, either by functional or physical depreciation. Looking at the question from the other standpoint, the earning power is no greater, and no less in one case than in the other, and from that standpoint it is not material whether the streets are paved or unpaved. Much can be said that the true value of the property is measured by its earning power. But these figures as to extra cost of laying pipe under pavements can be eliminated and the result in this case not changed.

Going Value Allowed.

The Master has found and fixed a valuation upon this property, as a going concern, as distinguished from the naked plant. As to this, both reason and authorities sustain him.

It took a long time to build up the system. First it had to get in touch with patrons, make contracts and install meters, and establish the business. During that period the capital stock was not earning what it should have earned. Now that it is a going concern, it is entitled to have these values considered, in arriving at the true valuation of the plant. Such reasoning is endorsed by courts, both national and state supreme courts, and such conclusions are the result

of sound reasoning. Such are the tests in all other vocations, and business enterprises.

Elements of Fair Return.

The water-works company claims that certain other specific things, by name, should be allowed, either by way of enhancing the value of the property, or that which would be the same thing, by calling them hazards and allowing such rates as would produce a reasonable revenue thereon. One of these is the fact that rates are subject, at any time, to change by the city council, subject to local prejudice and without experience or training with reference thereto; the hazard that the city, at any time, can force an involuntary sale by proceedings of condemnation; the fact that the franchise cannot extend beyond 25 years, with no assurance that it will be renewed; another competing plant may be allowed; the city may establish a competing plant; and other minor hazards.

There can be no question but that some of these matters should be given consideration. The greater the hazard, the higher the rate of interest. A farmer who observes his contracts and pays his debts, can gat a loan at a low rate of interest by a mortgage on his farm. A man whose credit is not good, and who can only tender security of a doubtful character, must pay a high rate of interest. This has always been so and always will remain so. The fact that the company's charter may be revoked by a forced sale, or that it may expire at the end of 25 years, and that it will be continuously kept in litigation, are all hazards, which in other business enterprises would increase the rate of interest that the borrower must pay, and justly entitles it to a higher rate of earnings than if its earnings were certain and fixed, and were in perpetuity or of long duration. But it is well nigh impossible to point out just what particular hazard will increase the rate of interest, or will entitle it to a higher rate of earnings.

Master's Valuation.

From the most exhaustive readings and consideration of the voluminous record in this case, a record of many thousands of pages, I not only cannot say that the findings of the master as to the value of this water plant have not been fairly stated by him, when he states that it is worth not less than $1,840,000, in round numbers, and perhaps that it is worth something like $15,000 in excess of that, but I think that the Master has been conservative in fixing this valuation. It can be well said that if he is in error, it has been by an under-valuation.

Net Return Less Than 8 Per Cent. and Unremunerative.

Taking into account the expenses of approximately $122,000 per year, the reduction proposed by the new ordinance would make the plant unremunerative to the extent that it is entitled to receive, considering the fair value of money in a state like Iowa. And, considering the hazards and liabilities, some of them certain and others contingent, and some of them destructive, an 8% return is moderate. But this proposed ordinance would allow nothing like 8%.

All fair-minded people should readily agree, and the defendant city and its officers ought to agree, that reasonable returns should be allowed to not only these investments, but these dangers and hazards, which clearly are to be taken into account, under the authorities.

Some of the leading cases which support the foregoing are the following:

City of Omaha vs. Omaha Water Co., 218 U. S. 180.

National Water Works Co. vs. Kansas City, 62 Fed. Rep. 853.

Spring Valley Co. vs. San Francisco, 124 Fed. Rep. 574.

Kennebec Water District vs. City of Waterville, 54 Atl. 6.

Brunswick, etc., vs. Maine Water Co., 59 Atl. 837.

Gloucester Water Co. vs. City of Gloucester, 60 N. E. 977.

Norwich Gas and Electric Co. vs. City of Norwich, 57 Atl. 746.

Galena Water Co. vs. City of Galena, 87 Pac. 733.

Newburyport Water Co. vs. City of Newburyport, 47 N. E. (Mass.) 533.

Town of Bristol vs. Bristol Water Works, 49 Atl. 974.

Wilcox vs. Consolidated Gas Co., 212 U. S. 19.

The foregoing authorities sustain the foregoing holdings.

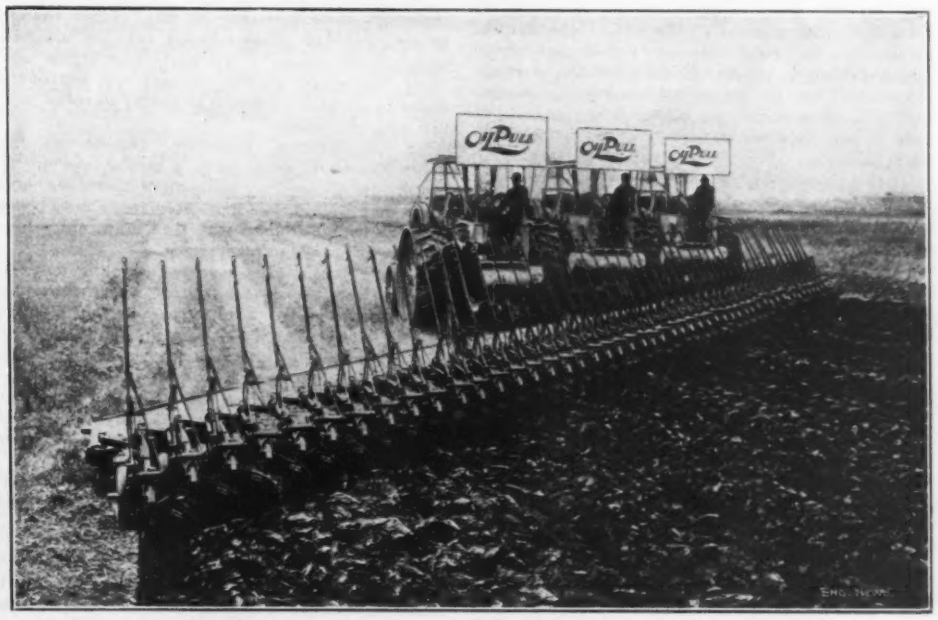
The exceptions, both of the city and of the water-works company, are all overruled.

The report of the Master is confirmed, and there will be a decree, enjoining the enforcement of the ordinance in question.

The local press of Des Moines announced on Oct. 23 that the city council had voted unanimously to appeal from the foregoing decision of the circuit court. It also announced that a commission had been created to appraise the value of the property of the company for purchase by the city.

Plowing at the Rate of 14 Acres Per Hour With a 50-Moldboard Plow Drawn By Three Traction Engines.

The accompanying illustration was taken Oct. 14 during a test of a 50-bottom plow unit at the agricultural college farm of Purdue University, Lafayette, Ind. It is claimed that this is the largest moldboard plow unit ever built. Eight or nine-bottom units are often used, pulled by a single traction engine, and a 16-bottom plow designed specially for light soils has been used in this country. It has been reported that 25-bottom units have been drawn in England by the cable system. Perhaps the nearest approach to the present 50-bottom unit has been made in California, where a number of gang plows have been chained together in combinations of 30 to 40 8 or 10-in. bottoms.



TEST OF A LARGE GANG PLOW WITH OIL TRACTORS AT PURDUE UNIVERSITY.

The 50-bottom plow was designed by Mr. W. L. Paul, of the Oliver Steel Plow Works, to whom is given credit, too, for the idea of using three traction engines abreast and for the design of the equalizer through which the pull of the engines is communicated to the plow. Each plow is arranged to rise or fall to a certain extent independently of the others to accommodate irregularities of the ground surface, and each is controlled by a separate lever. Four plowmen are required on the running-board to operate the levers, in addition to the three enginemen.

The three tractors used to pull the plow (made by the M. Rumely Co., of La Porte, Ind.) were driven by internal-combustion engines burning kerosene. The fuel used was of a low grade, costing about 4 cts. per gal. in large quantities. The three engines consumed a total of about 22 gals. per hour, and the fuel cost was thus about 6½ cts. per acre. It is stated, however, that the plows were set for a rather shallow cut, plowing about 4½ to 5 ins. deep. With this cut, a speed of about 2 mi. per hr. was attained. The width of cut was nearly 58 ft., giving seven acres per mile of travel, or 14 acres per hour.

A 30,000-HP. Steam Turbine Placed In Service by the New York Edison Co.

The largest electric generating unit yet completed was placed in service by the New York Edison Co. at its No. 1 Waterside Station on Nov. 3 in the presence of some 150 guests. The proceedings were particularly impressive to the visitors from the moment when Mr. Geo. B. Cortelyou, President of the Consolidated Gas Co., opened the throttle valve. The turbine was brought up to speed and, at the moment of synchronism with the other units of the station, was thrown onto the bus-bars of the station. Then one after another, six huge 5,000-HP. reciprocating engines, beside which the turbine appeared little more than an auxiliary, were shut down until finally the entire load of these units was carried by this turbine alone. There was no external evidence of the increasing load being imposed on the new machine other than that of a small dial indicating the number of steam nozzles that were being opened by the governor as more steam was required.

The new generating unit comprises a 20,000-KW., 6,600-volt, 25-cycle, three-phase generator and a 30,000-HP. Curtis steam turbine. The speed is 750 r.p.m. Steam is taken at 175 lbs. gage and 100° superheat, the consumption being 15 lbs. per KW.-hr. at full load. The machine is of the vertical-shaft type, and stands 35 ft. 7 ins. above the basement floor, occupying an area of 297 sq. ft. The total weight is 420 tons, and the rotor weighs 112 tons. This machine is one of a number which will eventually displace the older 3,500-KW. reciprocating-engine units with which the station was formerly equipped entirely. One such turbine unit occupies a space one and one-third that of an old engine-driven unit; by the change four times the generating capacity is concentrated on a given floor space.

Municipal Ownership of Water-works at Des Moines, Iowa, is proposed, and a commission of three has been appointed to value the works. Action has apparently been taken under a statute of 1909 (Chap. 45) which authorizes Iowa cities to apply to the State Supreme Court for a condemnation commission composed of three distinct judges. The commissioners in the Des Moines case are Frank R. Gaynor, of Le Mars; Charles E. Ransier, of Independence, and Robert M. Wright, of Fort Dodge. The Commission was ordered to begin its work early in November, 1911. A valuation of about $1,846,000 for rate-making purposes was recently fixed by a master and confirmed (Sept. 16, 1911) by a federal circuit judge in a suit brought more than three years ago.

The Economic Administration of Industrial Establishments.*

By JOHN CALDER,† M. Am. Soc. M. E.

(1) The Need for Greater Efficiency.

The files of the technical press and the proceedings of the engineering societies during the past ten years reflect the increasing attention which was given during that decade to the economic features of shop management.

That efficiency in manufacturing plants and their offices would become more and more a vital factor in such business was apparent from a brief consideration of the trade and traffic statistics of the United States Manufacturing Census as far back as 1900. These showed that proprietors expected to make on the average about 20% profit on their capital, however much it might have been watered.

The enormous dilution of capital in forming consolidations during the ensuing decade has rendered it impossible with unmodified organizations, except in the case of the monopolies, to keep up to the above profit. In many cases the margin has dropped to a very modest figure, and in some it has disappeared.

Forty years ago our decennial census showed that the capital required to produce a given quantity of manufactured goods was only 50% of the annual output. Twenty years later—in 1890—the capital required had risen to 70%, and in 1900, or within another decade, it had further risen to 75%.

In the latter year, $600,000,000 of the capital of the iron and steel industry, for example, produced products valued at $800,000,000, and at the present day the capital of the average manufacturing concern can be turned over only about once in nine months, instead of every six months, as formerly.

In the United Kingdom, where capital appears to be less watered, a turn over of capital twice a year appears to be below the average return, and Continental Europe also shows up favorably in comparison.

We need not dwell, by way of illustration, upon the statistical and economic facts of the transportation industry, which are well known to the present audience as a pressing problem of the day and one which the railroads, so far, have been invited to solve solely by internal economics.

The above condition of things is not as it should be, considering the great ability brought to bear upon American trade. There is no doubt that the real working capital at the disposal of our industrial managers—if known—would make a better showing for the United States, but it is worth while inquiring if we get full value from the present methods of expenditure. The returns from heavy capitalizations and enlarged plant facilities created during boom periods are not satisfying stockholders even in normal times, and are the first to be affected during a decline.

The function of organization in shop administration is not alone the important one of operating plants economically, but also to anticipate trade fluctuations, to measure up with care the prospective value and desirability of extensions, to check mere bigness of project and endeavor to make reasonable provision for a contracting expense of organization during a period of depression.

(2) The Importance of the Organization.

Taking the desire for more economical business administration for granted, consider for a little, in the order of their importance, the various factors which will influence the result.

At the outset, we must reckon with the fact that the *organization*, not the system, is the primary consideration. This is not the order of precedence prescribed by some professional systematizers, but any other is a mistake.

Every business worthy of the name must be provided with an organization, and no matter what particular system may be followed, it cannot attain economic distinction if it is not effectively organized.

The primary object of organization is to bring brainy men together for work and action. A wise organization seeks and encourages men of ambition. It believes that the ambitious man is not necessarily dangerous. It knows that success demands an aggregation of strong individualities, free to contribute their quota of wisdom, but loyally subordinating their individual preferences to the general policy once declared.

In order that its work may be well done and its action strong and forcible, the organization must move forward as a harmonious unit. No amount of clever scheming alone will secure this. Herein lies the task and the genius of the organizer of *men*, as distinguished from the mere systematizer of *things*. His work is much easier to talk about than to carry out, but it needs brief mention here.

When any business or industrial work becomes larger than its proprietors can take care of, they seek for assistance, and from that moment they and their delegate, the general manager, become organizers.

The organizer's success will depend not merely, or even chiefly, upon extended technical experience and close knowledge of the business, but upon his ability to select his assistants, to transfer his own work to them and to inspire those assistants with his own ideas, his own energy and his own ability.

Emerson says, "Every great business is but the lengthened shadow of one man," and he is right.

The modern administrator of industrial establishments is a manager of men rather than of things, and the human factor touches his business on all sides. I lay particular stress upon it at this stage, so that it may not get out of focus in an address which is chiefly devoted to an analysis of things.

An organization therefore, cannot go into commission. It must have a strong, resourceful leader and a carefully selected, well-trained, loyal and enthusiastic staff. This will only come through intimate contact with a man, not a mere machine or inanimate system.

Having chosen men, frequently young men, for their record and potentialities, particularly for signs of executive ability, a not too plentiful quality, they should be expected to win solely upon their merits and to make the most of the business by making the most of themselves.

Unless the leader sees and plans for an opportunity for a useful career, not only for himself but for his staff, he cannot reach the highest success.

The cold-bloodedness of some of the modern schemes for exploiting the higher human energies is not only repelling—it is a fatal defect.

(3) The Systematizer.

Organization, though the greatest factor in business, implies co-ordination, or system, and not much can be accomplished without the aid of the latter.

Business methods and apparatus, particularly those of mechanical and transportation concerns, are being closely scrutinized and many proposals made for securing greater internal economy. At such a time it is well to bear constantly in mind that any system, however attractive and justifiable in some of its features, is, like the plant itself, worth no more than it can earn.

No manufacturer is in business as a subject for experimentation which may not point the way but merely warn others from following. All money and worry expended on system beyond the earning point is wasted.

An admitted experiment of measured duration and conclusive nature is one thing, but a shop revolution covering years of transition experiences is irretrievable and usually unsupportable.

Dead uniformity and absence of scope in a system for individual initiative and incentive are not necessarily factors in securing what are the sole justifications for special outlays on system, viz.: Absolute certainty of increased economy, accuracy and dispatch.

In concerns in which system is an expensive hobby and not an economical tool, all kinds of extravagances will creep in and will be justified by some philosophy which ignores common sense.

One of the claims brought before proprietors by some of the external practitioners of system is that it will not only render their business self-perpetuating—most desirable end if attainable—but that it will also enable them to become, to a large extent, independent of their managers and higher executives.

This is a somewhat mischievous doctrine. No army of clerks, mechanically following planning instructions, however perfect, can take the place of the full use and recognition of able engineering administrators and shop assistants under any conceivable works system.

The human element in system as well as in organization, is half of the problem and there is a tendency to too great rigidity in most of the shop systems offered for general application.

It is not a recommendation for any business system, imported from the outside, but rather the reverse, that it should insist upon absolute conformity to type in details without regard to the problem in hand and the great amount of experience already acquired from it.

Some of the most practical modifiers of shop management are fully alive to this, but there is a tendency amongst the less wise to vigorously wield the new broom.

It is the belief of the writer that the best type of shop system is evolved, not from the outside, but in the shop itself through careful analysis of its special conditions and requirements by the responsible administrator thoroughly in sympathy with and experienced in advanced practice.

A busy and prosperous administration can sometimes be helped by system advice from the outside. It should never be controlled by it. The most natural tendency of the outside adviser without responsibility for current product and profit is to stereotype the detail of his previous limited practice and dry up the springs of initiative and suggestion within the plant.

The best system for any particular shop is that which will co-ordinate all the efforts of a good organization and which will draw out and suitably reward the best effort of everyone concerned, not forgetting the employer. The most suitable management for so doing will never be exactly alike in any two cases, though the principles followed may be identical.

(4) The System of "Scientific Management."

It was to an already progressing and intensively developing shop practice that there was presented, ten years ago, "Scientific Management," a phrase to conjure with, which is much in the air at present.

It appeared at first with a more modest title, and made its appeal through the ordinary professional channels to the engineer. It was a worthy appeal, based upon a quite unusual amount of self-denying investigation; but it did not receive the immediate consideration it deserved. This was partly because the straw man which it set up and repeatedly and vigorously knocked down was merely a lay figure and not really representative, as alleged of the best existing shop practice.

In the case of the more open-minded and thoughtful engineers, ready to learn from any source, the "science" of the movement was accepted with considerable reservation; and from the humanitarian point of view, the illustrations used by the gifted author of the system laid it open to not unjustifiable attack and to the complaint that though a deeply interesting experiment had been made, it did not justify the far-reaching generalizations based upon it.

In the ten years which have elapsed, professional efficiency engineers with no such experience as the able author of "Scientific Management" have multiplied somewhat more rapidly than the demand for this service would warrant. Quite recently "scientific management" itself has caught the fancy of the press and of the man in the street, and has been let loose through a popular propaganda upon an indiscriminating public. It will come back to its moorings after a while.

Actually, the particular system described and advocated by Mr. Fred W. Taylor has made relatively little progress, and, while economic administration of industrial establishments has been not a little quickened by its advent and discus-

*A paper read at a Joint Meeting of the Engineering Club and the Railroad Club of Altoona, Pa., Oct. 25, 1911.

†Manager Remington Typewriter Works, Ilion, N. Y.

sion, the most of the general advance has been the result of causes operating before that event, and much of it has not been along the specific lines of such proposals in "Scientific Management" as are original with its author.

The fact of the matter is that Mr. Taylor's "Scientific Management" is a very big and difficult task, requiring professional ability of the highest order. Stripped of the data, apparatus and phraseology which have led careless readers to think of it as a new way of running machinery, of paying men, of avoiding labor trouble, of insuring dividends, etc., it is neither more nor less in its essence than a proposal to revolutionize our industrial life.

Viewed in that light, it is a most interesting and suggestive speculation which well repays close study by engineers. It presents itself to the shops in complete technical detail—a most expensive detail; and many businesses cannot contemplate the years of outlay involved before the returns promised should accrue. The author of the system is entirely frank on this aspect of the case; and system practitioners whose promises have a "get-rich-quick" flavor are certainly not installing the genuine "Scientific Management."

The writer believes thoroughly in the principles enunciated by Mr. Taylor, but is of the opinion that they are offered for application in a detailed system too complicated, rigid and unyielding for immediate application to every-day needs.

Shop management is an art rather than a science. It has to deal with too many unknown quantities and variables either to aspire to scientific rank or to adopt a fixed creed. Few individual businesses can afford the interference and expense involved in carrying out effectively the extensive scientific programme of the proposal under discussion.

By professional societies or national agencies, many shop problems still unsolved might possibly be greatly assisted without the risk of interfering with business; but the installation of the whole machinery of scientific management has been very seldom attempted.

Nevertheless, though committal of a shop to one rigid programme of outside origin in all its implications—and the control of the business, it must be remembered, is an invariable stipulation—is not, in the writer's opinion, desirable; there is plenty of scope for more systematic analysis and regulation of shop processes and expenditures. The business world, and engineers in particular, owe much at present and will owe more to the ability and devotion with which the author of "Scientific Management" has elaborated and advocated his particular combination of things old and new.

(5) The Proper Use of System.

There are several rules in regard to office and shop routine which the writer would recommend all managements to observe, irrespective of the class of work done.

(1) Have a well-considered system of doing things, definite and businesslike in all departments, not an imitation of something else, but one designed for your own case.

(2) See that a broad view of the subject is taken and provision made for properly dovetailing the various department systems.

(3) Make the connection clear to all employees by the use of a chart, such as Table 1 of this paper. Such a table is self-interpreting, and saves much explanation.

(4) Have as little system and as few forms as possible. Make them a means, not an end. There are many daily items of shop practice being perpetuated in expensive card systems to-day of which no use whatever is being made or is ever likely to be made.

(5) Do not treat the system as a fetich. It is a good servant, but a bad master. So much of it as is justifiable is merely organized common sense. Prune and pare your system until it gives the utmost economy and dispatch.

(6) Do not fail to note closely what your system costs, and if it is really paying its way. Very few experts can answer that question. With many it is purely a matter of faith.

(7) Be always on the outlook for improvements and suggestions from any responsible quarter and discriminating in adopting them.

The writer has spoken of useless records, with reference to data which need not be recorded at all in permanent form. Some other records are useless, because their form renders them so for the purpose of frequent and rapid reference. Still, other records are useless because they are inaccurate and unreliable.

The writer has heard it urged, in all seriousness, that detailed shop and cost data cannot be trusted; but this is simply a plea for slovenliness, which the users would not tolerate in their own technical spheres.

It is just as easy and cheap to collect—almost automatically in a good system—correct figures as it is to record inaccurate ones, and the man who knows exactly what he is accomplishing will always come out ahead of his competitor, who only thinks he knows.

The college boy more and more realizes nowadays that mathematical propositions are few and far between, and stiff commercial and shop problems many in the practical engineering field; but a good deal of dearly bought experience could be purchased more cheaply, we believe, if more of the money expended so freely in our universities was devoted to lectures by practical men on the real needs and practice of every-day manufacturing life.

It is a hopeful portent also that the manager and his assistants are no longer too busy to interest themselves in the details of factory accounts. These become, when properly presented, exceedingly interesting and suggestive documents, and the amount of modern system which we need bids fair to amply justify itself, particularly in lean years, by its results. The rest is dead weight, and should go promptly overboard.

(6) The Variety of Management Problems.

Systems of management are necessarily as various in their details as the business conditions which have to be met. The simplest condition is that of a concern manufacturing a thoroughly standardized product which, under no circumstances, will they adopt or modify for special use. As a business policy, this may be carried too far, and the product may be out of date before the fact is realized.

In such a business, however, at one sweep, many of the difficulties experienced by general engineering courses are disposed of, and attention can be concentrated on a limited number of definite problems, the satisfactory solution of which may be attained by gradual and experimental stages.

In plants in which standardization, a manufacturing basis of business and reasonable frequency of improved product are carried out to their fullest extent, the shops and executive staff have practically no necessary relation with the customer. They deliver the finished product to the warehouse of the sales organization, and the problems which their system should solve are purely internal. The lighter machinery manufacturers of standardized contrivances are embraced in this class.

At the other end of the scale we have the business in which a complication of agencies, some within and many outside the plant, must be skillfully tied up to each other by red tape—as little as possible, however, if they are to produce the desired results by a given time. These problems of successful management include such industries as shipbuilding, or mechanical operations dependent upon the simultaneous progress of civil engineering work at a distance; also work involving combinations of contracts.

In a class by themselves are problems like ship docking and repairing and locomotive overhauling, where the time during which a large investment is earning nothing is a governing consideration.

Between these extremes, namely, where cost is the determining factor on one hand and speed of completion on the other, there are all possible variations, no half dozen of which could be efficiently managed on precisely the same system.

(7) The Engineer and Shop Management.

The writer's own philosophy and practice in the economic administration of industrial establishments is the development of a quarter of a century's experience in the shops, ranging from the designing and engineering involved in the building of ships, locomotives, stationary engines and mill machinery to the manufacture of coal-handling plants, typewriters and adding machines.

These 25 years have been marked by a steady extension of the engineer's art, which now underlies a large part of our modern civilization. But the development has been intensive as well as extensive. Within the shop the managing engineer and his staff have advanced from more or less subordination to clerical controllers under the general system to no mean understanding of the once mysterious departments of accounting and costing.

In many cases, through the domination of the engineer in management, empirical rating and arbitrary labor in shop practice have become things of the past.

Most of the shop practices described in this paper are neither original with the writer nor with the modern advocates of shop systems. They are, in fact, and have long been, the commonplaces of shop management.

The minute sub-division of processes in manufactures was predicted and its advantages set forth in 1776 by Adam Smith, the Scotch philosopher at the University of Glasgow and the gifted author of "The Wealth of Nations." Sixty years later, the principle was firmly established, and Charles Babbage, the noted English mathematician and mechanician, described in 1834, in his "Economy of Machines and Manufactures," the minute division of labor in repetition work obtaining in his day in various industries which he illustrated. He also furnshed a complete philosophy of the subject and examples of calculations as to the limits of reasonable investment in labor-saving machinery.

Industries, such as textiles, in which machinery reigned supreme at a very early stage, were most affected by the new principle which evolved quite naturally with the dawn of modern industrialism.

In our own day, practical political economy has been somewhat neglected by engineers, and three-quarters of a century after Babbage we find the division of labor by machines carried much farther than the divisions of handicraft, which he also advocated and described.

In many cases with us, the "trade" is still the economic unit instead of the "task," and this is particularly so in the metal manufacturing and building industries; not only so, but labor has shown no disposition to improve the "trades," many of which are notoriously wasteful of time and effort.

There can be little doubt in these days, when the high cost of living is a live topic, that economic necessity, if not inclination, will finally drive us to take up in all seriousness the conservation and intensive application of human energies in every department of activity, distributive as well as productive, and that new avenues of usefulness will open up for the production engineer.

It has not occurred to many engineers, as distinguished from the makers of purely machine-made products, to apply the intensive method of shop operation thoroughly to anything except very light and very simple repetition operations, and to not many even of these.

The second half of this paper is devoted to illustrating the principles already outlined in their application to a particular works problem. It is not in their novelty, but in their combination, intensive use and application with a measure of success to special and exacting business conditions that they perhaps merit some attention, and possibly convey, in no spirit of dogmatism, a few suggestions applicable, with suitable modifications, to other lines of work.

It may be emphasized here that the underlying practical motive of the system is not indiscriminate speeding at the expense of the workers, but the securing by co-operation of the economies

obtainable through either anticipating or locating and removing all wasted time and ineffective or unnecessary effort and expense, whether clerical, manual or mechanical. It is directed towards enabling employee and capitalist alike, under the most favorable conditions to make the most of the opportunities of the working day, and in so doing a very large part of the usual burden is removed from the shoulders of the employee and placed upon the organization.

ORGANIZATION AND SYSTEM IN THE REMINGTON TYPEWRITER WORKS, ILION, N. Y.

In illustration of the above discussion a brief statement is given below of a particular administrative problem involving the economical handling of the labor of 2,500 people, of whom 500 are females, and the production of about 100,000 typewriting machines a year and a considerable number of spare parts.

Each machine contains about 2,500 highly finished individual pieces, each of which passes through from 6 to 30 machining and other manufacturing operations; and many trades and handicrafts are required for the production.

Operations on the typewriter begin with the pig-iron and on its packing box with the log and practically all of the unit parts are originated within the plant. A total of about one million interchangeable metal pieces of several thousand varieties must be produced daily and an equivalent number of parts be built each day into the different models and lengths of writing line of the Remington standard typewriter, its tabulator and its adding and subtracting attachment.

A machine may be built to write in any one of 84 distinct languages and its keyboard, literary, commercial or technical, may be any one of 500 already registered or it may be altogether special.

Orders for the Remington typewriter reach the works from every part of the world and only a small portion of the demand can be anticipated by stocking finished machine product. A rush order for any standard machine not in stock should be shipped by express, without interruption of the regular flow of work, in not more than 48 hours after its receipt.

The requirements outlined demand a very special method study and division of labor in the preparatory, machining, parts, assembly and machine building departments and all the conditions must be met with economy as well as accuracy and dispatch.

The economic problem expressed in a sentence is to produce daily the full quantity of satisfactory machines in all the required varieties by the most efficient shop and labor arrangements and with a minimum of fixed and cash capital locked up in the process. An organization and a system of management which will accomplish this and continue to do so with harmony and satisfaction to employer and employee alike is the desired end.

For the past eight years the problem just stated has been met by the organization charted in Table I. Except in that every arrangement of functions has been based on business facts, not preconceived fancies, and on careful analysis, no "scientific" claim is advanced for the system, which is modified in its details as often as desirable.

A summary of the system expressed on the chart is now given but no forms are illustrated as only principles and broad outline are dealt with.

The organization is indicated on the chart by the numbered and grouped functions which the various assistants control. The figures below each division on the chart indicate the total number of employees engaged in that section and afford by comparison some idea of the relation under the system of direct labor upon the product to the various preliminary and operating services found necessary.

A manager (1) is in control of the whole works. He exercises this supervision directly (2) over all the seven executive departments (4 to 10) with an engineer specializing in the same at the head of each.

A superintendent (3) acting under the manager, controls the separate factories, for parts and machines respectively, through the two assistants and the foremen (11 and 12) who supervise the 25 manufacturing shops.

The customer's order department (4) handles all such correspondence, issues all production orders for the building of machines, either stock or special, to the machine assembly factory (12), packs and stores the finished machines on perpetual inventory and ships and bills them and all other products sold.

The purchasing department (5) buys all material and supplies on the specifications of the works and designing engineers (7 and 8). It will be noted that with the function of purchasing is combined that of receiving and storing upon perpetual inventory. The writer has found this combination economical.

The purchasing engineer has not only to order the goods advantageously and timeously, but has also to secure prompt delivery, verification and safe storage and on demand from the production order department (6) he has at all times the undivided responsibility for "producing the goods."

The production order department (6) controls all work demanded from the eighteen shops (11) producing finished parts and delivering them to its stock room.

This department runs, almost automatically, seven-tenths of the plant on a perpetual inventory basis. The flow of work in every shop and at every stage in each shop and the quantity of every finished part of some 5,000 varieties in the stock room is on record at all times, both in the departments and in the stock-room office.

The clerks in every shop report direct to the production order chief. They receive for the foreman the order to produce the routine and the material, and get from the foremen and inspectors the certified finished work, for record and for storage or for passing on to another process or department. The production order department's ordering and controlling operations are based upon its finished stock perpetual inventory figures for each of the parts carried and on data for which the manager is responsible.

TABLE I.—ORGANIZATION OF REMINGTON TYPEWRITER WORKS, ILION, N. Y.

1. MANAGER (2500)	2. EXECUTIVE DEPARTMENTS (363)	4. Customers' Orders and Shipping (42)	Correspondence on Orders; Stock of Finished Machines, Packing Room; Shipping and Billing Machines and Parts
		5. Purchasing and Stores (34)	Purchasing Raw Material and Supplies; Receiving Clerk, Teams, R. R. Siding; Raw Material and Supply Stores
		6. Finished Parts & Production Orders (18)	Finished parts Stock Room, Simple & Compound; Issues all Production Orders for Parts and Mat; Issues all Parts for Machine Manufacture
		7. Works Engineering (90)	Light, Heat, Power, Accident Prevention; Millwrights, Electricians, Plumbers; Fire Corps, Watchmen, Yard Labor
		8. Designing & Tool Engineering (106)	Inventing, Model Making, Specifications, Catalog; Designing Parts and Jigs, Toolmaking
		9. Inspection (35)	Materials, Work in Process & Finished, New Tools
		10. Accounting, Labor & Motion Study (20.)	Cashier & Bookkeeping; Costing & Inventories; Industrial Betterments; Time Records & Pay Roll; Rate & Method Testing; Works "Bulletin"; Suggestion System; Foremen's Club House; Works Band; First Aid
	3 MANUFACTURING DEPARTMENTS (2137)	11. Manufacture of Parts Assistant Supt. & Foremen. (1653)	Pattern Shop; Brass Foundry; Iron Foundry; Japanning; Tinsmith; Drop Forging; Punch and Press Work; Automatic and Hand Screw; Annealing and Hardening; General Grinding; Light Drilling and Milling; Cast Iron Drilling and Milling; Polishing; Plating and Buffing; Wood and Rubber Working; Typemaking; Assembling Compound Parts; Tool Maintenance
		12. Manufacture of Machines Assistant Supt. & Foremen. (484)	Assembling Machine Frame Group; Assembling Machine Type Bar Group; Assembling Machine Carriage Group; Assembling, Final Stage; Adding Special Features; Rebuilding Machines; School of Repairing

Planning.

The writer does not favor the running of shops such as those here described, or indeed any class of manufacturers, by fiat in every detail from a central planning department. Attractive as a general scheme, the complete centralization of the initiative and thinking of a plant is neither "scientific," economical nor practical. If attempted, to square with some theory, it undoubtedly slows up the plant and lessens the internal "good will," a most valuable asset.

In the works system here described each section of the organization in conference with the manager and superintendents has its appropriate part in planning and complete records of the same are readily accessible.

The works engineer (7) plans for all power and plant general services, including safety precautions and all maintenance of buildings and machinery. The special accident prevention measures adopted at these works were fully described by the writer in the February, 1[illegible] "Journal of the American Society of Mechanical Engineers."

The design engineer (8) plans for invention, model making, part design, part [illegible]ing and toolmaking and the preparation and revision of the catalogue of parts which is identical for sales and shop use.

In this connection a simple grouping in tens of thousands up to 99,000 has been adopted, which reveals the group by inspection and a simple or compound part by even or odd ten thousands, for the many parts listed and leaves ample room for additions in each group. The writer has found that symbolic or mnemonic systems of nomenclature, while sometimes useful in accounting, are usually undesirable and unnecessary in the shops and can be replaced by simpler numbering methods.

The engineer (8) foremen (11 and 12) and motion study department (10) plan for and test machine tools, small tools, shop routine and speedy operation and assembly methods, all of which, when approved, are standard till modified.

The inspection department (9) plans for, executes and reports to the manager on inspections for quality of the raw material, and at the prescribed stages of new tools, parts and new machines. They also report on all missing and spoiled work, assigning responsibility whenever possible and the cash value of the losses. The prescribed inspection tests are standing orders until modified.

The manager (1) in conjunction with the production order department (6) and taking account of the shop capacity for every part and present and forecasted trade conditions, plans for

(1) A daily "flow" of certain standard parts which is a standing order till modified.

(2) The quantity "to order" and "to stock" of every other part manufactured, also a standing order when fixed.

(3) In conjunction with the customers' order department (4) the manager also determines daily the number and varieties of typewriting machines which are to be built from the parts in "stock" and in "flow."

(4) In conjunction with the purchasing engineer the manager executes all contracts for material and controls the amount of capital tied up in stores.

The second items listed, viz.: The "quantity to order" and "to stock" of over 5,000 different pieces are the most important of all the figures requiring to be planned. They are practically an epitome of the shop's ability to produce in every respect. They are used with confidence on every occasion by the production order department and control what is by far the largest part of the pay-roll expenditure.

For every part, maximum and minimum finished stock figures are established. These figures are based upon a careful analysis of the time of "flow" of the part from start to finish and on existing trade conditions. "The quantity to order" is so fixed that, if the order is placed when the perpetual inventory shows the "normal" figure in stock, the first portion of the new order will be coming into the stock room before the minimum is reached. The same regulation is adopted for all stocks of raw material and of finished machines.

The fixed capital investment in buildings, machinery and jigs is used intensively and does not permit of assistance by heavy stocking.

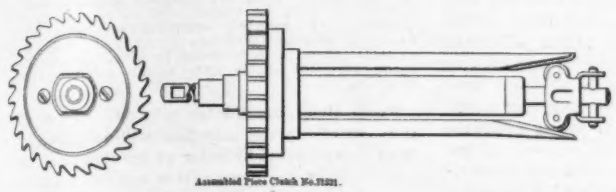
In times either of inflated or depressed business the scale on which material is purchased, or parts and machines manufactured is at once modified by the management by suitably altering the permissible maxima and minima and the quantity to order for every item.

The governing consideration of the system is: Sufficient production with minimum investment of fixed and cash capital.

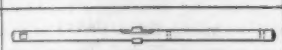
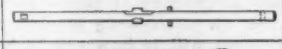
The general result of the cooperative system described is that all preliminary planning and basic figuring are carried out by the practical experts and departments best fitted to do so either singly or in conference and unnecessary intermediaries are dispensed with.

The results are fully recorded and subject to criticism and suggestion from any source. The production order and stock room force (18) is small for an organization of 2,500 people and there is no intervening army of clerks, nominally doing this work, but actually merely manipulating card records for the data on which, and the interpretation thereof, others with technical or practical experience are, or should be, responsible.

TABLE 2. DIVISION OF LABOR AND SPEED OF WORKERS IN ASSEMBLING SMALL INTERCHANGEABLE PARTS. EXAMPLES WHERE WOMEN, BOYS AND MEN ARE USED.



Assembled Piece Clutch No.31321.

Stage No.	Unit Parts 16 in Number Assembled in 10 Stages	Operations in Sequence	Grade of Labor	Average Time Including Stage, from Records of 500,000 Pieces Min.	Sec.
1		Ream 2 holes 0.67"in Roll Holder No.30670 on speed lathe	Women	0	7
2		Assemble roll holder No.30670 2 rolls No.30699 and 2 pins No.67645 at bench	Boys	0	45
3		Ream 1 hole 0.186"in clutch frame No.30381 on speed lathe	Women	0	5
4		Tap 3 holes 0.60"-36 in clutch frame No.30387 on tapping machine	Men	0	16
5		Ream 2 holes 0.500" and 0.625" in shaft No.31030 on speed lathe	Women	0	10
6		Straighten shaft No.31030 on bench block	Boys	0	6
7		Put pin No.65610 in shaft No.31030 with bench fixture	Boys	0	20
8		Put in washer No.30006 and assemble tube No.31321 and spring No.67230 at bench	Men	2	24
9		Bend and gage clutch jaws No.30690 in bench vise	Men	0	21
10	See Full size sketch	Assemble clutch jaw No.30690 ratchet No.30679, frame cover No.30336, 3 screws No.70025, and roll holder comp., with pins No.64659 at bench	Men	1	32
	The direct labor cost of assembling 1 clutch No.31321 is 0.764 cents	Average time to assemble 16 unit parts to form clutch No.31321	Women Boys and Men	0	46

The Foremen.

The work being wholly of a repetition nature, though to limit the investment it is not processed in every particular every day, the foremen are not functionalized out of existence as proposed in some systems and made to feel that they count for little in the general scheme of things.

Relieved of all clerical duties and, because of the motion studies and straight piece work based upon them, of practically all policing duties, the foremen are left free to manage their own shops and to make the most of—if possible to suggest improvements upon—the equipment and instructions given them.

Under these conditions they prove to be the most valuable employees on the pay roll and the most fruitful in good suggestions. Busy foremen are not able to carry out with the necessary detail and thoroughness the preliminary rate and method tests required by the system, if these were left to the shops, progress would be much slower, but they are keen critics of the results when presented for application and not seldom are able to "go one better."

The accounting, labor and motion study (10) is the last executive group to receive special mention here. Just as the plant production is normally run by the production order department, its methods of operating, its rates and its apparatus for every single part have to be certified in all cases by the rate and method testing division before production on any scale is authorized in the shops.

This small group of independent experts, whose operations were described in detail by the writer in the January, 1911, "Journal of the American Society of Mechanical Engineers," are an essential part of the rating and method planning system and thoroughness of their work is the justification for a simple straightforward piece rate system of payment in which the exceptional worker retains his surplus and is not asked to share it with his employer in any form as is done in systems where the rating is largely guess work.

Briefly stated the designing engineer (8) having previously consulted all the foremen and experts interested, turns over his jigs and tools and proposed shop routing for any new part for criticism, motion, speed and fatigue studies. These are carried out by the testing experts of the accounting department rapidly and with precision and, subject to acceptance by inspectors, practically the whole direct labor of the plant operates under some 20,000 straight piece rates. Some account of the methods and results of tests is given in the appendix to this paper. The division of labor and motion study results are such that workers properly selected and trained make good wages in all departments, while furnishing product at a satisfactory labor cost.

Costing.

It follows from the system of payment applying to a large proportion of the employees that, in addition to the day-work accounting on plant maintenance and betterments, the determining of the direct cost of a very varied product is a simple matter. It is needless to maintain a clerical staff large enough to cost every recurring order for each part. Mass costing is found on this system to be more accurate than that carried out continuously in great detail but the time and quantity cards are accumulated for every order and every part is costed by selection at intervals.

Every standard unit cost is, of course, modified when new methods permit of cost reductions and the operating expense is very closely recorded and studied. The perpetual inventories in quantity of material and parts in process and finished, already mentioned, are represented in the accounting department by similar cash values. The books of the plant are closed monthly and a full statement of balances, of finished product, costs and of profit, and loss is issued early in the succeeding month.

Industrial Betterment.

In concluding this description of a system which solves the administration problems of the Remington Typewriter Works some reference may be made to several social features.

TABLE 3.—Time Study of Average Performance on Straight Piece Work to Instructions in Molding the Seven Pound Base Casting of the Remington Standard Typewriter.

CONDITIONS OF OPERATION.

(a) The molding machine used is a specially adapted pneumatic vibrator.
(b) The machine holder is not permitted to possess or use any hand molder's tools other than a shovel and riddle.
(c) All imperfect molds due to irregularities, duly reported, in the machine or patterns furnished are paid for.
(d) On all imperfect castings due to errors in molding or pouring the metal the workman loses his piece labor.
(e) The size of the snap-flask handled is 14 ins. × 19½ ins.; the cope being 3½ ins. deep and the drag 4 ins. deep.

ANALYSIS OF ONE MOLDING AND AVERAGE TIME FOR EACH OPERATION BASED ON RECORDS FOR 400,000 MOLDS.

Operation in sequence.	OPERATOR'S INSTRUCTIONS.	Average time in seconds.
	First Stage: Molding of "Drag."	
1	Pick up "follow-board" and place table of machine	2
2	Pick up pattern and place on "follow-board"	5
3	Pick up and place "drag" and put retaining band in it	7
4	Fill riddle with sand	2
5	Riddle sand on pattern	5
6	Fill up "drag" (two shovelsful)	30
7	"Strike-off" with squeezing board and place latter	4
8	Swing machine yoke over and squeeze "drag"	5
9	Roll mold over on table	3
10	Remove "follow-board"	2 —65
	Second Stage: Molding of "Cope."	
11	Shake parting sand on pattern	4
12	Pick up and place "cope"; fill riddle with sand and spread on pattern	20
13	Fill up "cope" (three shovelsful), pack sand at edge of cope with shovel handle	28
14	"Strike-off" with squeezing-board, place latter, swing machine yoke and squeeze	10
15	Removing squeezing-board	2
16	Start vibrator, blow off mold with air nozzle, cut sprue hold and lift "cope"	10 —74
	Third Stage: Finishing of Mold.	
17	Start vibrator, blow off mold with air nozzle and draw pattern from "drag"	14
18	Place "cope" on "drag," closing the mold	7
19	Remove the snap-flask	7
20	"Stop-off" the carrier	15
21	Place mold on casting floor	8 —51
	Total time for completing one mold, 3 mins. 10 secs	190

Analysis of Operator's Working Day: Ten Hours 7 to 12 and 1 to 6.

Daily earnings, $3.50. Labor cost, per cast mold, 3½ cts. Imperfect castings, 5%.

		Hours.
Variation of Employment	Molding at machine	6
	Keeping sand close to machine, cleaning pattern and shovel	1
	Bench, casting floor and pouring-ladle preparation	½
	Resting and absence while molding	½
	Pouring the day's work—105 molds—with rests	2
	Total	10

The "Works Bulletin," a monthly periodical edited by the manager, is issued to the foremen and assistants with news likely to interest and encourage them, with judicious criticism or appreciation of departmental performances and with full acknowledgment and a detailed list of all the "Good Suggestions" adopted during the previous month and the names of the contributing foremen. Much rivalry is aroused and each issue contains 50 to 150 accepted suggestions of considerable value. In advancing a foreman his record in this respect is considered in addition to executive ability.

A "Suggestion System" separate from that of the foremen is conducted for employees and a

prize of not less than $20 in gold is awarded for each accepted suggestion or group of suggestions. The ordinary employees are not nearly so fruitful in suggestions of value as the foremen, but the door for them is kept wide open and all necessary privacy for this purpose is afforded.

Amongst other industrial betterments arising out of an atmosphere of good feeling are a library and a hospital, the gifts respectively of C. W. Seamans and H. H. Benedict, the founders of the Remington Typewriter business.

A well-equipped club house and recreation park, honor badges for long and efficient service, a works band, a baseball league and a field day are some of the other social institutions.

The policy of the corporation has been merely to provide such facilities as are not available from public enterprise in a small community and not within the means of the employees, all the projects mentioned being otherwise wholly managed and financed by the workers themselves.

Extent of the Works.

As a result of the organization and the system followed, a very compact industrial unit is obtained occupying less than 300,000 sq. ft. of floor area with its manufacturing operations and covering with its buildings and yards a rectangular plot of land only 1,000 ft. long by 250 ft. wide. There is no waste or unused space anywhere within the various buildings or yards and the time occupied in mere handling or transport of work in process is cut down to a minimum owing to the ordered sequence of the operations, their close proximity and the rapid flow of the stock.

The buildings contain 1,600 machine tools operated by mechanical power and 60 operated by hand labor, besides a large quantity of finely made and costly jigs, tools and fixtures and other labor saving equipment. Many of the machines have been specially designed and constructed at the works. The greater portion, however, are standard machine tools with slight adaptations for repetition operation by straight piece work under studied conditions which enable them to be used on an intensive scale not attempted in ordinary engineering. The automatic screw machines, for instance, 160 in number, are all run on a piece work system under close inspection and the ordinary, somewhat indifferent, day operator of a group of machines has been transformed into a busy and vigilant opponent of idle spindles.

In Appendix "A" are given examples of the preliminary design and equipment conditions prescribed for fulfilment on every unit piece before manufacturing is attempted.

In Appendix "B" is given a summary of the testing conditions for manufacturing methods on a piece—in this case a compound assemblying operation is selected.

Appendix A.

Conditions to be fulfilled for every part before beginning its manufacture:

(1) Part to be designed with quick and economical molding, machining and assembling in view.
(2) Efficient tools, jigs and fixtures working to practical limits in dimensions and fits to be designed, made, and properly maintained.
(3) The prescribed quality of work—neither more nor less—to be attained.
(4) Efficient parts inspection service to be provided, securing in every department adherence to the prescribed limits and the earliest possible rejection of all defective unit parts.
(5) Shop routings to be adopted in each machine and other departments which will produce the fitting surfaces in the condition permitting "least work" in assembling.
The total abolition of the file or other cutting tools at the bench is to be aimed at.
(6) The highest speed of assembly is to be arranged for.
(7) The classes of labor available are to be properly selected, graded and trained for the task.
(8) The division of labor upon the task is to be as large as possible.
(9) Care is to be taken that the preliminary time and method tests by the skilled demonstrators is carried out thoroughly, including the elimination of lost motion and full criticism of the condition and suitability for assembly of the machined unit pieces.
(10) The efficiency of the machine tool and other mechanical facilities provided by the management for aiding the work of preparing, machining or assembling parts should be freely criticised.

Appendix B.

Conditions to be determined for an assembly task by the motion and method study department before reporting speed possibilities for rate fixing on new piece or new method:
(1) Criticism of all previous operations having been given in detail as above, the following conditions are to be determined, the motions being carefully studied as to their necessity and timed as to their duration.
(2) Determine best height and position of seat or chair for the operator (male or female) at the bench or machine.
(3) Determine best position in front, or on right or left of operator, of the several bench tools of each unit piece comprised in the assembly task.
(4) Determine the best position of the hand tools and apparatus which the operator has to pick up, apply and lay down again.
(5) Determine the advantage, if any, which an ambidextrous operator will have at any stage and arrange for the cultivation of that faculty.
(6) Determine the best arrangement for bringing forward and removing the work without interrupting the assembly process.
(7) Make progressive time studies for each of the movements decided upon as necessary under the best conditions as above determined and combine them on the principle of "least work" with proper allowance for rest periods and avoidance of undue fatigue.

The Examination for the Appointment of Civilians to the Corps of Engineers, United States Army.

As stated in these columns some months ago, the President last winter signed an act of Congress authorizing the commissioning each year of a certain number of civilians as officers in the Engineering Corps of the U. S. Army, a corps that hitherto has been filled entirely from the honor graduates of the Military Academy at West Point. It is now announced in an official circular from the War Department that the first examinations for the eligible list from which these appointments are to be made will take place Jan. 12, 1912, under conditions specified at length in the circular. As this is the first time that the opportunity to enter the Engineer Corps of the Army has been offered to young graduate engineers, it is expected that the interest in the examinations will be very wide and the Department will have a large list from which to select the ten or more officers which the deficiency in the Corps calls for this year. Full information regarding the examinations and eligibility requirements is given in the circular, which may be obtained by writing to the Adjutant-General of the Army, U. S. War Department, Washington, D. C., for "General Orders No. 139."

According to the law

To become eligible for examination and appointment, a civilian candidate for the appointment as second lieutenant must be an unmarried citizen of the United States between the ages of twenty-one and twenty-nine, who holds a diploma showing graduation in an engineering course from an approved technical school, and is eligible for appointment as a junior engineer under the Engineer Bureau of the War Department. Selection of eligible civilians for appointment, including term of probation, shall be made as the result of such competitive examination into the mental, moral and physical qualifications, and under such rules and regulations as shall be recommended by the Chief of Engineers and approved by the Secretary of War.

In addition to this, the circular states that

eligibility for original appointment as junior engineer (civil, mechanical and electrical) under the Engineer Bureau of the War Department is determined by the rules of the U. S. Civil Service Commission and may be secured (1) by passing successfully the examination prescribed by the Civil Service Commission for such position; (2) by promotion in the Engineer Bureau of the War Department, and (3) by transfer from another branch of the departmental service to the Engineer Bureau.

It would appear, therefore, that the examination is open only to engineers already in the Engineer Bureau of the War Department, or to those who have passed the examination for junior engineer under that Bureau, even though they have never taken the position for which such a successful examination would qualify them. Any other engineer desiring to make himself eligible for the examination would first have to take and to pass the examination for junior engineer and be declared eligible by the Civil Service Commission, or, if he be a civilian engineer in some other branch of the departmental service, be transferred to the Engineer Bureau of the War Department. We understand that every effort will be made to aid the engineers of the latter classes to render themselves eligible under the law; the Civil Service Commission is to provide the requisite "junior engineer" examinations some time this fall and the matter of transfer from one branch of the departmental service to the Engineer Bureau of the War Department will be favorably considered by the authorities. In spite of these provisions, it is evident that the first commissions from civil life in the Engineer Corps will be most apt to be made from among the young, unmarried civilian attachees to the Army Engineer Corps.

Those eligible for appointment must submit a sufficient testimonial of their moral character and must pass a physical examination by the Army surgeons. In addition, each candidate who successfully passes these requirements must take a mental examination in English, grammar and orthography; general history, civil government; elementary French, German or Spanish, as the applicant may elect; the elements of constitutional and international law and the law of contracts; physics, including electricity, magnetism, heat, sound and light; chemistry; geology and mineralogy; elements of electrical engineering; general and practical astronomy; topography; hydrography; geodetic surveying; descriptive geometry and drawing; theoretical and applied mechanics; theory and practice of engineering construction, and materials of construction. According to the circular

The scope of the examinations upon the various subjects shall be such as to test thoroughly the knowledge of these subjects which candidates should have acquired while pursuing engineering courses in good technical schools or in preparation therefor and is covered by what is comprised in standard, well recognized text-books. No candidate will be considered as having passed a satisfactory mental examination who fails to attain a general average of at least 80% on such examination, or who fails to obtain a mark of at least 70% of each and every subject included therein.

From those candidates who pass the examination satisfactorily, selection will be made by the War Department in order of relative merit as determined by the competitive mental examination, for probational appointment as second lieutenant in the Corps of Engineers. The mere fact that a candidate has passed satisfactorily the competitive mental examination will not give him any right or title to a probational appointment. Acceptable candidates from approved technical schools who can show also at least one year's continuous service as a commissioned officer in state military organizations, or at least one year's training in a well established military organization of their technical school, and who received at every mental examination an average of 90% or more, shall be given preference over all others who cannot show proof of any such military service or training. Probational appointment as second lieutenant in the Corps of Engineers will be made for a period of one year, and persons so appointed shall be entitled to the rank, pay and allowances of second lieutenant. The candidates on acceptance of their probational appointment will be assigned for instruction and observation during their year of probation to a battalion of engineers stationed in the United States. At the end of one year the officers will be examined upon various military subjects and upon the successful passing of such examinations will be appointed as second lieutenants in the Corps of Engineers to rank as such from the date of their probational appointments and will then be immediately assigned to duty with engineer troops.

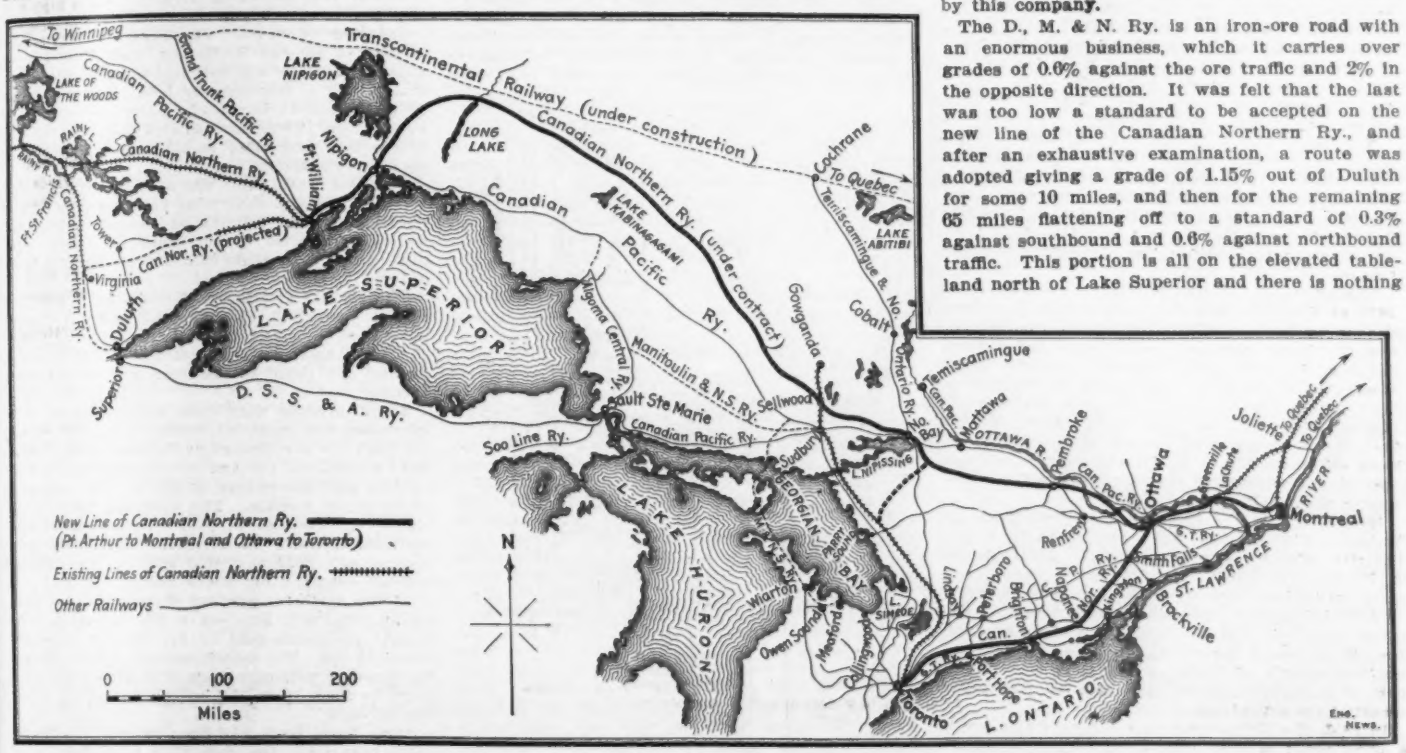
The pay of a second lieutenant in the United States Army is $1,700 a year, plus a certain allowance for commutation of quarters. This is increased to $2,000 for first lieutenant, $2,400 for captain, $3,000 for a major, $3,500 for lieutenant-colonel and $4,000 for a colonel. These salaries are increased 10% for every five years' service in the army. Ten per cent. extra allowance of salary is given for service outside of the United States, except for service in Porto Rico and Hawaii.

The New Water-Supply for Lincoln, England, has more than usual interest because of the typhoid outbreak which occurred there in 1905, and which for a time necessitated the purchase of water from carts at 2d. (4 cts.) per Imp. gal. The new supply is pumped from four "boreholes" at Elkesley, from a normal depth of 28 ft. below the surface, and is conveyed 22 miles by pipe to a steel tank of 360,000 U. S. gals. capacity, supported on a brick and stone tower 110 ft. high. Water from this tank is supplied to a high-level district. The surplus goes by gravity through the city mains to a new 7,200,000-gal. (U. S.) reservoir. The opening of the works was the occasion of a local festival.

New Links in the Canadian Northern Railway System.

The railway system of the Canadian Northern Ry. Co. comprises two distinct and widely separated groups of lines, in the eastern and western provinces of Canada respectively, but the company for a long time has had in view the work of connecting and extending these two groups so as to form a through route from the Atlantic coast to the northwest and eventually a complete transcontinental line. The general situation is shown on the accompanying map.

The eastern system extends from Quebec to Montreal and Ottawa, and includes a separate or isolated line extending 300 miles from Toronto north to Sellwood, which is about 30 miles north of Sudbury on the Canadian Pacific Ry. The western system comprises a network of lines in the great agricultural districts of northwest Canada. Its main line, however, extends from Port Arthur (on Lake Superior) to Winnipeg and thence to Edmonton (Alberta); beyond this latter point it is headed across the Rocky Mountains to a Pacific coast terminal and port. The construction of this western part of the railway system was described in our issue of April 5, 1906.



MAP SHOWING THE NEW PORTIONS OF THE CANADIAN NORTHERN RAILWAY, LINKING UP ITS EASTERN AND WESTERN SYSTEMS.

An important step has been taken recently towards linking up the eastern and western systems by the award of a contract for the construction of a line 540 miles long from Port Arthur, Ont. (the present terminal of the western system), eastward to Sellwood, connecting with the line to Toronto. A further gap of 300 miles remains to be closed on the line from Sellwood to Ottawa and Montreal, and this section is now under survey. In the negotiations with the government, Sudbury figured very largely as a point on the new line, and the mileage on the original location started from Sudbury Junction, the nearest point. As now located the line runs from Sellwood, which is 23 miles north and on a completed line which now reaches Gowganda, 53 miles from Sudbury Junction. The junction of the Montreal line will probably be at a point about 11 miles north of Sudbury (and 310 miles west of Montreal). The completion of the new lines shown on the map will have a marked influence on the railway system of Canada as well as upon the Canadian Northern Ry.

SELLWOOD AND PORT ARTHUR LINE.—The construction work on the new 540-mile line between Sellwood and Port Arthur will be, for the most part, of a very ordinary character. The most difficult and interesting section will be the 120 miles into Port Arthur. This includes some heavy side-hill work in rock excavation along the shore of Lake Nipigon, with a tunnel 1,100 ft. long; also an expensive bridge over the Nipigon River, a diversion of the river, and a viaduct 2,200 ft. long and 130 ft. high across the Blonde River valley. The other more important river crossings (from east to west) are the Ground-Hog, Trout, Kapuskasing, Missinabie, Kabinakagami, Morrison, Kenogami, Sturgeon and Black Sturgeon rivers. The ruling grades are 0.6% against westbound trains and 0.5% against eastbound grades, all compensated. These have nowhere been exceeded for the entire distance between Montreal and Port Arthur, and have been used, in fact, only in a few instances. The ordinary standard is 0.4% in either direction. The standard of curvature is 6°, which has been exceeded at only half a dozen points; for some hundreds of miles on the interior plateau curves of 4° are the rule.

SELLWOOD AND MONTREAL LINE.—The main transcontinental business is to and from Montreal, and arrangements are being made to complete a through line from Sellwood to this point. The main portion of this will be a new line eastward from near Sellwood to Ottawa. The company already has a line running eastward from Ottawa along the west bank of the Ottawa River and crossing the river at Hawkesbury, beyond which point it runs eastward to Quebec. To complete the connection between Ottawa and Montreal, the old Carillon & Grenville Ry. (broad gage, 5 ft. 6 ins.) has been purchased; this will be rebuilt to standard gage and extended to Montreal. It is said that this extension may include a long tunnel, giving an entrance to Montreal from the north. The building of this line will effect the completion of a direct through route between tidewater and the great interior territory of the Northwest which is being so rapidly settled and developed.

The standards of grades on this Montreal-Sellwood line are the same as on the Sellwood and Port Arthur line, except that there is at one point a grade of 0.5% (compensated for curvature) against the eastbound traffic. To reduce this to 0.4% would involve much additional distance and curvature as well as heavy rock work. For this reason it was considered better to face the distant possibility of having to work this as a "pusher grade," than to increase the mileage for the passenger trains.

DULUTH AND VIRGINIA LINE.—The Canadian Northern Ry. has a branch (known as the Duluth, Winnipeg & Pacific Ry.) from its Winnipeg & Port Arthur line westward from Fort Frances through the Rainy Lake district to Virginia, Minn., where connection is made with the Duluth, Missabe & Northern Ry. so as to form a route between Duluth and Winnipeg. A new line is under construction from Virginia to Duluth, so as to give the company its own line throughout. The terminal points being the same as those of the Duluth, Missabe & Northern Ry., the route unavoidably lay through pretty much the same country, but there is no paralleling. The distance is about 75 miles. A line is to be built also from Duluth eastward to connect with a branch line from Port Arthur, which is owned by this company.

The D., M. & N. Ry. is an iron-ore road with an enormous business, which it carries over grades of 0.6% against the ore traffic and 2% in the opposite direction. It was felt that the last was too low a standard to be accepted on the new line of the Canadian Northern Ry., and after an exhaustive examination, a route was adopted giving a grade of 1.15% out of Duluth for some 10 miles, and then for the remaining 65 miles flattening off to a standard of 0.3% against southbound and 0.6% against northbound traffic. This portion is all on the elevated tableland north of Lake Superior and there is nothing in the construction out of the ordinary. The grading alternates between clay and gravel, cuttings and muskegs, and two or three moderately bad sink holes are the only interesting features.

The 500-ft. lift from Lake Superior to the plateau is nearly all on a steep and very broken rock side-hill. It includes a 500-ft. tunnel and some very heavy rock work, aggregating 150,000 cu. yds. in a distance of about eight miles; also two or three permanent trestles. The entry to Duluth is all elevated, and grade crossings of streets have been practically eliminated. The Canadian Northern Ry. owns its own yard and water terminals in West Duluth, but it is proposed to run over the tracks of the Northern Pacific Ry. into Duluth proper and also by way of the Grassy Point bridge into Superior, Wis.

OTTAWA AND TORONTO LINE.—To complete an eastern system connecting the principal cities of eastern Canada, a line is to be built across Ontario from Ottawa to Toronto. This also is shown on the map.

The surveys and locations of the lines above described have been in charge of Mr. Henry E. Wicksteed, Chief Engineer of Surveys, Canadian Northern Ry. The construction of the two lines from Sellwood to Port Arthur and from Virginia to Duluth is under the direction of Mr. H. T. Hasen, as Chief Engineer, with offices at Duluth, Minn.

The Development of an Anthracite-Culm Briquette Plant on a Commercial Scale.*

By CHARLES DORRANCE, JR.†

Culm is a general term used in the anthracite regions for many years to denote a mixture of coal, bony coal and impurities which is sent to the refuse banks. Thus, 35 years ago culm contained the pea and buckwheat sizes of anthracite; but to-day, and as mentioned in this paper culm is used specifically to denote the material which passes through the smallest screen in the anthracite-breaker. The smallest size of commercial anthracite is known as No. 3 buckwheat, barley, or bird's-eye coal, and is ordinarily made through a round-punched plate having openings 3/16-in. in diameter, and over a round-punched plate with opening 3/32-in. or 1/16-in. in diameter. Thus culm will consist of coal, bony coal, slate, gravel, iron pyrite, etc., ranging in size from 3/32-in. down to dust. Other local terms for culm are "slush," "silt," and "dirt."

History of Culm Briquetting.

The first experiments towards the utilization of anthracite culm by briquetting, and the first briquetting work done in this country, were in 1872 at Port Richmond Piers, Philadelphia, Pa., by E. F. Loiseau. Clay was used as a binder and the finished briquette was waterproofed with shellac, etc. Excessive cost was given as the reason for discontinuing work at this plant.

The Delaware & Hudson Co., in 1876, built a plant at Rondout, N. Y., which operated until 1880. Gas-tar was used as a binder, and anthracite screenings were briquetted for engine fuel. Excessive cost, poor results in firing, and the tendency of the fuel to cut the boiler-flues were given as the reasons for discontinuing the manufacture.

The next plant was built by E. F. Loiseau about 1878, at Nesquehoning, Pa., near the No. 1 or Nesquehoning Colliery of the Lehigh Coal & Navigation Co. Pitch was used as a binder, and several samples of these briquettes were recently found along the bottom of the culm heap at Nesquehoning. These briquettes are about 4 ins. square, and contain coal from pea size to dust. Except for rough corners, they are perfect in shape and have suffered little or no deterioration. The high cost of production was the chief reason for abandoning the work.

In 1890, a plant of English design was built at Mahanoy City, Pa., to make briquettes from anthracite culm for engine use of the Philadelphia & Reading Railway. At first 18-lb. briquettes were made, but afterwards the size was changed to 2-lb. briquettes. The binder used was coal-tar pitch imported from England. The chief reasons for abandonment were inability to get a steady, uniform supply of binder, small margin between cost of manufacture and cost of coal, and poor results in practical use.

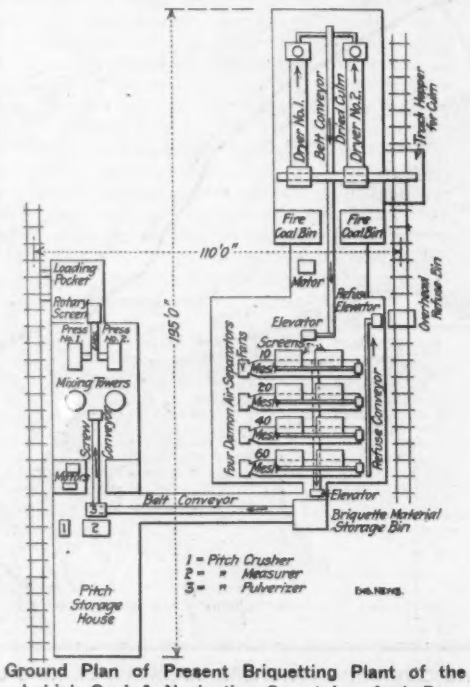
In 1905, the New Jersey Briquetting Co. erected a small plant in Brooklyn, N. Y., which was later moved to Perth Amboy, N. J., and is now in operation. The anthracite culm briquetted is shipped from the mines of the Susquehanna Coal Co. in the Lykens District. Melted coal tar is used as a binder. The briquettes, of "pin-cushion" type, averaging in weight about 2 ozs. each, with specific gravity of about 1.25, are used for domestic purposes.

In 1906, the Scranton Anthracite Briquette Co. erected a plant at Scranton, Pa., near the Storrs colliery and washery of the Delaware, Lackawanna & Western Railroad. The plant consists of one press of the roll, or Belgian, type, said to have a capacity of 500 tons per day of 10 hrs. The Delaware, Lackawanna & Western Railroad uses 200 tons of these briquettes daily on freight locomotives, burning them mixed with No. 1 buckwheat and bituminous coal.

In 1908, the Lehigh Coal & Navigation Co. built a small experimental plant at Lansford, Pa., and in 1909 began marketing briquettes from this plant for household use. The plant was destroyed by fire in December, 1909, and a new plant was put into operation in March, 1911, having two presses of the Belgian type, and a capacity of from 15 to 20 tons per hour.

This practically reviews to date the history of the briquetting of anthracite culm in the United States. Many small ventures have been started and companies formed, some of bona fide producers, but the greater number being stock-selling propositions, or secret-binder exploitations. It will be noted that there has been but one of the anthracite producing companies—the Lehigh Coal & Navigation Co.—which has directly done any work along these lines since the experiments in 1876 of the Delaware & Hudson Canal Co. The failures of the first four plants naturally had a great deal to do with this condition, but when we consider that, due to cheaper pitch and better machinery, the cost of briquetting has probably been materially reduced since 1890, the date of the abandonment of the last plant, while the cost of anthracite coal has steadily increased and will probably continue to increase, the two principal reasons for these first failures seem to be to a great extent eliminated.

The commercial tonnage of anthracite per year is about 60,000,000 tons, and a conservative estimate of the amount of culm produced annually would be about 8% of the commercial tonnage of coal, or about 5,000,000 tons. This percentage is higher in the southern and lower in the northern anthracite field. The average cost of disposal of this culm is about 2 or 3 cents per ton, depending on the methods employed and the local conditions. In many cases the culm is flushed back into worked-out rooms or chambers in the mines to permit the removal of the intervening pillars. This disposal is often given as an argument against briquetting, but it is hardly admissible, since our German brother finds that sand and



Ground Plan of Present Briquetting Plant of the Lehigh Coal & Navigation Co. at Lansford, Pa.

gravel are better for the purpose, and he refuses to use good coal, for which he has paid to mine and prepare, as a substitute for non-combustible material. At all events, the method of using anthracite culm for mine-filling can hardly be classed as a step towards the scientific conservation of natural resources.

In most cases, where culm is not flushed back, it is either mixed with jig and platform slate and sent to the refuse bank, or washed into slush-dams and there settled. The former method means that the culm is practically thrown away for good, since it is doubtful whether it could be extracted from the banks except at great expense unless worked again for washery purposes, and to-day few refuse banks are rich enough for that treatment. The latter method is cheap, and the culm can be reclaimed easily at a small cost. One of the large anthracite companies has ordered that all its culm must be kept separate from other refuse, having in view its reclamation at some future time.

Leaving aside the value received from culm used for flushing purposes, to-day the annual production of 5,000,000 tons of culm, averaging 75% of pure coal, entails, in addition to a cost per ton of mining equal to that of the best chestnut coal, a further cost of 2 or 3 cents per ton for disposal, with a revenue which is negligible. As an economic question, therefore, its utilization is a most intensely interesting subject.

There are two general methods which have been suggested for using culm for fuel: one, combustion either in pulverized state or without pulverizing, in special furnaces; the other to briquette it. The first method will not be taken up in this paper, but from a question purely of fuel value in dollars it is perhaps the better way if feasible. But little expense, either in labor or material, is added to the culm, if burned direct, and thus the resulting cost per British thermal unit, or per horse-power produced, is small. On the other hand, the efficiency of combustion will probably be low, and its use adapted only for steam-producing purposes, where the fuel must have a very low selling price. Briquetting, on the other hand, necessitates considerable addition to both material and labor before the briquette can be made. But the resulting fuel can compete with the higher-priced domestic fuels and has a high fuel efficiency. From an academic standpoint briquetting also has the further advantage that if briquettes are used for domestic purposes it will mean a 15% longer life to anthracite as a domestic fuel, postponing the day when the cost of production of anthracite will bring its selling price beyond the reach of all save the well-to-do.

Preliminary Experiments.

About the middle of 1907, the Lehigh Coal & Navigation Co. began experiments towards the utilization of culm. The investigation was in charge of George B. Damon, Fuel Engineer. A small laboratory was established in Mauch Chunk, Pa., which a few months later was transferred to the mines at Lansford. After preliminary investigation, it was decided to do the first work in briquetting and later to take up experiments in direct combustion.

The first work done was a thorough systematic series of tests to determine both the physical and chemical characteristics of the culm from the various collieries of the company. Tests were also run on culm from collieries of the other large anthracite companies.

The results of this work indicated the fallacy of the prevalent idea that all culm is largely pure coal. On the contrary, as a general rule, the finer material in culm was found to carry higher ash than the coarser part of the same sample.

Tests indicate that culm averages about 25% incombustible material, which is probably much too high for a satisfactory domestic fuel. Due to wide variations, the ash in culm may run as high as 40% and the nature of the impurities is such as to cause trouble. The finer the material the larger the amount of pyrite it carries, and the material through No. 60 mesh, when panned in a prospector's gold pan, will show on the clean-up a thick covering of "fool's gold."

Of the material passing through No. 100 mesh about 75% will stay on a No. 200 mesh. The weight per cubic foot of dry culm will average about 55 lbs. The moisture from culm made in a wet breaker will vary from 30% when first loaded down to from 10 to 15% after more or less drainage in cars.

After these tests had been finished and the results tabulated, the following conclusions were reached in regard to the briquetting of this material:

1. Size.—The material was readily adaptable without crushing, but it was judged that the very finest material (passing No. 60 mesh) would perhaps have a deleterious effect on the resulting briquette, and should be rejected.

2. Moisture.—The culm would probably have to be dried before briquetting.

3. Impurities.—It was decided that a method of reducing the impurities from the coal must be devised, if the briquette was to be used for a domestic fuel.

As drying at some period of the briquetting process was deemed advisable, it was decided to investigate the feasibility of pneumatic separation, and an experimental separator was built. It consisted of a narrow box-like compartment about 13 ft. long, 18 ins. wide, and 10 ft. high. In the front end at the top was placed a hopper, from which the culm was fed by gravity to a horizontal feeding belt. This belt fed a steady shallow stream of culm into the separator at a joint just above the opening through which air was drawn in at the front end. At the back end of the separator was another opening which led to a Sirocco multivane fan. The bottom of the separator consisted of 24 small boxes, or bins, each about 6 × 18 × 18 ins. in size. These boxes fitted closely to each other, and air-tight doors were made along the bottom of the separator, so that after each test they could be removed. Both the front and rear openings of the separator were adjustable in vertical position and in area, and the positions of the feed-hopper and belt were also adjustable. There were air-tight windows in the top and sides of separator, and electric lights

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†Lansford, Pa.

were placed in its interior, so that observations could be made during the tests.

In the operation of the separator, the fan was started and a current of air was sucked past the front opening on through the box-like body of the separator and exhausted outside the laboratory. A thin layer of dry culm was fed into this air current at the front opening and carried towards the rear of the separator. The impurities in the culm, having a specific gravity ranging from 2.5 for slate to 5.2 for pyrite as compared with 1.6 for coal, should settle out of the current first, while the lighter coal should be carried further along. The above action was found to take place to a certain degree.

These tests were run for a period of about six months, until all variations of air, openings, feed, etc., had been tried. The results showed that under the most favorable conditions, from 50 to 60% of the culm could be obtained as briquetting material from the separator, with a reduction in ash of from 2.5 to 3.5%. This means that nearly half of the original culm would have to be thrown away, and the culm recovered would still be nearly as high in ash as it was before treatment. A great deal of the worst impurities was eliminated, however, and the briquetting material recovered was very much improved in size, since the oversize and the very fine dust were eliminated. The main cause for these poor results was the fact that the culm was not sized closely enough for good separation. The small pieces of slate and the large pieces of coal, both having the same weight, would fall into the same box.

From the above tests, however, a process was outlined and patented, the patents being assigned to the Lehigh Coal & Navigation Co. These patents control both the machinery and the process. In a general way, the process as outlined is to dry the slush, and separate it by air into the three following products from the separator: (1) Material which settles in the front end of the separator and is large in size. This is to be used in a gas producer to generate gas, which in turn is to be used to dry the original culm before separation. (2) Material which settles out of the air current in the middle of separator and is to be used as briquetting material. (3) Very fine material, the last to settle at the rear end of separator, is to be burnt direct in a special furnace, on a surface which is preheated by producer gas from the first product.

The following table gives the average physical and chemical properties of these three products, as shown by results obtained in tests:

	(1) Producer Material, %	(2) Briquette Material, %	(3) Furnace Material, %
Quantity of the original culm by weight	25	55	20
Quantity of incombustible	28	20	25
Quantity of material, 10-mesh or larger	30	2	0
Quantity of material between 10 and 60-mesh	68	90	35
Quantity of material smaller than 60-mesh	2	8	65

Experimental Plant.

A small experimental plant to demonstrate the process was built in the fall of 1908. As shown in Fig. 4, the equipment consisted of a rotary drier 3 ft. in diameter and 15 ft. long, to which the culm was fed from a track-hopper. The dry slush was elevated after leaving the drier to a Damon air separator, in principle like the small testing separator, but with three bins at the bottom instead of the 24 small boxes. The front bin collected the producer material, which was elevated to the charging platform of a 250-HP. suction gas producer. The producer consisted of the producer proper, the scrubber, and the receiver, and the gas produced was burned in the furnace of the rotary drier.

The middle bin of the separator collected the briquetting material, which was conveyed in a screw conveyor to the briquetting press. The pitch binder, measured and pulverized, was fed into this conveyor with the coal, and the mixture was elevated to the mixing tower of the briquetting press, where superheated steam was introduced and the pitch melted. The heated mixture was then fed to the press. The briquetting equipment was made in Belgium by Robert Devillers, and the press was the ordinary roll type, making egg-shaped briquettes, each weighing 1.5 oz.

The third bin collected the fine furnace material, which was rejected because no provision had been made for a furnace to burn it, due principally to lack of space.

The plant was started about the middle of November, 1908, and experiments were made during the winter of 1908-1909; but the work was not entirely successful. It was found that the producer material was too fine to be used in the gas producer, and No. 1 buckwheat had to be used in its place, the producer material being rejected. The drier was not adapted for drying the slush, and its capacity was very small. However, about 500 tons of briquettes were manufactured during the winter and burning tests, etc., made on them. Various pitches were tested as binders, and a great deal of data obtained on binders, power required and pressing.

In the spring and summer of 1909, more than 1,000 bbls. of briquettes were sent as samples to various retail coal dealers in the Eastern States, and the results were so favorable that in June the plant was started to manufacture boulets (as the smaller briquettes are called) for the domestic trade. Due to the fact that the capacity of the drier was so small, the press could not be worked steadily, but the drier was operated 24 hours per day, which gave enough material to make about 40 tons of product per day. The boulets found a ready sale in New England, and the plant was worked steadily up to December, 1909, when it was destroyed by fire. During this time about 6,000 tons of boulets were marketed, all for domestic consumption.

The results from a sales standpoint were so favorable that work was immediately begun on designs and plans for a commercial plant. Several different plans were discussed before reaching a final decision. Some time prior to the fire, tests had been made in the small testing separator with sized culm, which showed that if the culm was screened into four sizes—material over No. 10 mesh, and material over No. 60 mesh—and each mesh material run through the separator by itself, the results were very much better than those obtainable with the unsized culm. A recovery of 75% of the original culm was made, with a reduction in ash of from 6 to 8%, which meant a combustible value of the resulting briquette as high as the average nut or stove anthracite. It was decided, therefore, to size the culm before separation in the new plant.

Present Plant.

The construction of the new plant was commenced in the fall of 1910, and the plant put in operation in March, 1911. The accompanying illustration gives a ground plan of the plant.

The operation, as now conducted, is as follows: The culm is loaded into steel gondolas of 100,000-lb. capacity at the Lansford colliery of the Lehigh Coal & Navigation Co. and dropped to the siding of the briquetting plant, which is situated close to this colliery. The culm is dumped into a track hopper and elevated to the drying plant. Here the culm passes through two 30 × 6-ft. rotary-kiln driers, and is dried by direct contact with the heated gases of the drier furnace. The dried culm is then conveyed on a belt conveyor back to the separating building, where it is elevated to the top or screening floor. Here the culm is run over four sets of vibrating screens. The first set of screens has an extra scalping-screen arrangement by means of which any commercial sized coal which may be in the culm is saved and returned by chutes to the drier building, where it is burned in the drier furnace. The very fine culm passing through the last set of screens is conveyed to the refuse conveyor.

Four Damon air separators are placed under the four sets of screens, and the sized culm from each set of screens is fed to each separator. The refuse or slate from each separator feeds into a screw conveyor running along the fronts of separators. This conveyor feeds into an elevator, which discharges the refuse into an overhead steel bin, from which it is discharged into railroad cars and sent to the Summit Hill mine fire for slushing. The purified culm from each separator feeds into a screw conveyor running under the four separators and is elevated to a 50-ton storage bin.

The culm is fed in a measured stream from the storage bin on to a belt conveyor, which takes it to the mixing house, where the binder is added. Coal-tar pitch, used as a binder, is cracked to "pea and dust" size in a set of rolls. The cracked pitch is elevated to a pitch-measuring device, which, by means of a friction spool-and-wheel drive, has variable speed and feeds a measured amount of pitch to the squirrel-cage pulverizer, which pulverizes the cracked pitch, and feeds it into a screw conveyor along with the measured stream of culm from the belt conveyor.

The dry mixture of pitch and culm is conveyed to the briquetting building, and elevated to the two mixing towers of the presses. Here the mixture is heated with superheated steam and the heated mixture is fed to the presses. The briquettes are elevated directly from the presses to the bin, from which later they are loaded into cars. Before dropping into the pocket, they pass over a rotary screen which removes the fines and returns them for rebriquetting.

The operation of the plant and process to date has been successful. No large mechanical troubles have been encountered. Tests of power consumption, drying, and separating have been conducted, and results have been up to expectation. The cost of manufacture during the first month of operation, with all the mechanical troubles consequent to starting up, and a production of less than one-seventh the full capacity, was within a few cents of the estimate of cost of manufacture.

Following are the results obtained in the different steps of the process:

DRYING.—Approximate capacity of each drier, about 10 gross tons of dry culm per hour; moisture evaporated per pound of coal burned, 9 lbs.; coal burned per square foot of grate surface per hour, 8 lbs.; moisture evaporated in percentage of wet material entering the driers, 13.8%; power required for drying, elevating and conveying, 15 KW.; labor required for drying: 1 fireman at 17.5 cts. per hour; 1 laborer unloading culm, 13.5 cts. per hour.

SCREENING AND SEPARATING.—Enough No. 2 and No. 3 buckwheat coal is reclaimed from the culm to fire the driers, this material running in sizes: Buckwheat, 60.0; No. 20 mesh, 35.0; and smaller, 5.0%.

The screens give the following results in sizing:

	1st set, %	2nd set, %	3rd set, %	4th set, %
No. 10 mesh and larger	24.7	0.6	0.0	0.0
No. 20 mesh	70.0	60.5	6.3	0.0
No. 40 mesh	4.5	34.6	66.2	12.2
No. 60 mesh	0.6	4.0	24.8	69.4
Smaller	0.0	0.3	2.6	18.4
	99.8	100.0	99.9	100.0

Depending on the position of the adjustable slate gate, the following results may be obtained in the separators:

	Position No. 1, %	Position No. 2, %	Position No. 3, %	Position No. 4, %
Quantity of original culm recovered for briquetting	90.2	88.5	87.0	80.1
Quantity of original culm refuse	9.8	11.5	13.0	19.9
Reduction in ash for briquetting material	3.7	4.1	4.7	7.4
Quantity of ash of refuse	65.2	55.2	54.6	54.4

Power required for sizing, separating, conveying, etc., 65 KW. Labor required, 1 oiler at 17.5 cts. per hour.

MIXING OF BINDER.—No trouble has been experienced in handling and mixing the binder. The pitch has been shipped in bulk loaded in box cars, and during the summer we may have trouble from softening. The measuring machine works satisfactorily, and the only labor used is that of one man at 13.5 cents per hour to feed the pitch to the rolls.

BRIQUETTING.—At first considerable trouble resulted from improper feeding of the mixture to the presses, but this has been eliminated by using 400° superheat for the steam and then cooling the mixture as it leaves the mixing tower by means of a fan cooler. An extra elevator had to be built to return the fines which were taken out at the lip screen of the loading pocket. Labor required, 2 pressmen at 17.5 cents, and 1 loader at 13.5 cents per hour. Power required, 50 KW.

The whole plant is operated by nine men, including the foreman, and the total power consumption is about 135 KW. The hourly production of boulets, or briquettes, from both presses, is from 16 to 17 gross tons.

A Transporter or Ferry Bridge over the River Tees at Middlesborough, England, was formally opened on Oct. 17. This bridge differs from the one at Newport, England, described in Engineering News of Oct. 11, 1906, in having a cantilever span in place of the usual suspension type. The total length of the bridge and cantilever arms is 850 ft.; the span across the river from center to center of towers is 570 ft., each cantilever arm being 140 ft. long. The height of the bottom chord above high water is 160 ft. The steel caissons for the tower foundations were sunk to a depth of 90 ft. on one side and 70 ft. on the other. The tops of the towers are 250 ft. above low water. The cantilever arms are anchored to concrete blocks vertically beneath their ends by wire cables. The ferry car is 39 × 44 ft., and is capable of transporting 600 foot-passengers and six vehicles. The bottom of the car is level with the roadway on either side of the river. The car is driven by cables from a power-house on one bank of the river by two 50 B. HP. electric motors, and the trip from shore to shore is made in two minutes. One motor is sufficient to operate the car, the other is kept in reserve in case of a breakdown. The amount of steel in the structure, including caissons, is 3,200 tons. The total cost of the bridge, including approaches, is approximately $410,000. The bridge was built under the supervision of Mr. S. E. Burgess, M. Inst. C. E., Borough Engineer to the Corporation of Middlesborough, by the Messrs. Sir William Arrol & Co., Ltd., of Glasgow.

The Pittsburgh Flood Commission's Report: Storage Reservoirs Recommended.

The Commission organized by the Pittsburgh Chamber of Commerce three years ago, following the severe flood damage experienced by Pittsburgh in 1907-8, to investigate possible methods of protecting the city against floods, has completed its report, which is now in the printer's hands. Through the courtesy of the Commission we are enabled to print herewith the opening chapter of its report in which the results of its investigations are summarized. It will be seen that the Commission recommends unqualifiedly the construction of storage reservoirs on the tributaries of the Allegheny and Monongahela as by far the best method of flood prevention.

In order that due weight may be given to this important recommendation, it should be understood that it is made on the authority of a number of well-known engineers. The officers of the Flood Commission are H. J. Heinz, President; Albert J. Logan, H. D. W. English, Vice-Presidents, George M. Lehman, Gen. Secretary. The engineering committees of the Commission were made up as follows:

Engineering—E. K. Morse, Chairman; Emil Swensson, Vice-Chairman; Geo. S. Davison, Paul Didier, Julian Kennedy, Morris Knowles, George M. Lehman, W. G. Wilkins.

Flood Prevention—W. G. Wilkins, Chairman; Morris Knowles, George M. Lehman, E. K. Morse, Emil Swensson.

Flood Protection—Emil Swensson, Chairman; Paul Didier, Julian Kennedy, George M. Lehman, E. K. Morse.

Sewage Disposal—Morris Knowles, W. G. Wilkins.

George M. Lehman, Engineer in Charge; Kenneth C. Grant, Principal Assistant Engineer.

The chapter of the report entitled "Results of Investigations" follows:

The investigations and surveys of the Flood Commission, and studies based thereon, as fully described in the following chapters of this report, enable the Commission to make the following statements:

1. Floods at Pittsburgh are increasing in frequency and height.

2. There is every possibility that Pittsburgh will some day experience a forty-foot flood.

3. The damage at Pittsburgh resulting from a flood of a given height is steadily increasing.

4. The direct losses due to flood damage at Pittsburgh amounted to over $12,000,000 in the last ten years, while in one year and five days, between March 15, 1907, and March 20, 1908, three floods occurred, causing a direct loss at Pittsburgh of about $6,500,000.

5. If works for flood relief are not carried out, the direct losses due to flood damage at Pittsburgh alone will, on a conservative estimate, amount to $40,000,000 in the next twenty years.

6. The flood losses along the Ohio Valley in one year, 1907, are stated, in the preliminary report of the Inland Waterways Commission for 1908 to have amounted to over $100,000,000.

7. Flood relief by some form of local protection only, without storage reservoirs, cannot be recommended because:

(a) Such protective measures would give local relief ony.

(b) Such local relief would be the only benefit derived.

(c) Dredging alone, without reservoirs, would not reduce floods sufficiently, and a wall would still have to be built.

(d) The wall, without reservoirs, would have to be too high and would be too costly.

8. The flood water that would otherwise cause damage can be impounded in storage reservoirs, and by this means floods can be prevented.

9. There are many favorable reservoir sites of large capacity available for flood water storage on the drainage areas bove Pittsburgh.

10. Forty-three sites have been selected and most of them completely surveyed by the Flood Commission, the others having been studied from existing topographical maps and by means of partial surveys.

11. From a study of the relative effectiveness of the various projects it was determined that adequate flood reduction at Pittsburgh could be obtained with 28 of these reservoirs, while a final analysis reduced the number to 17.

12. If the Seventeen Selected Projects above referred to had been in operation, without any wall, the storage of flood water in these reservoirs would have reduced all past Pittsburgh floods to below the danger mark, or 22-foot stage, with the exception of the great flood of March, 1907, which would have been reduced from a stage of 35.5 ft. to a stage of 27.6 ft.

13. Supplementing the Seventeen Selected Projects by a wall along the low-lying portions of the river bank would confine all floods, including a possible forty-foot flood, within the river channels.

14. Flood prevention by storage reservoirs is possible and practicable, and is recommended because:

(a) The flood relief would be extended over hundreds of miles of tributaries and of the main rivers, including the Ohio for many miles below Pittsburgh.

(b) The impounded flood water, with proper manipulation of the reservoir system, would considerably increase the low-water flow of the tributaries and of the main rivers.

(c) This increased low-water flow would greatly aid navigation and interstate commerce.

(d) The increased low-water flow would notably improve the quality of the water for domestic and industrial purposes.

(e) The sewerage problem of Pittsburgh and of many other communities along the rivers would be simplified.

(f) The public health would be protected against the dangers arising from the unsanitary conditions caused by overflow and by extreme low water.

(g) A considerable amount of water power would be incidentally developed.

15. The solution of the flood problem, therefore, becomes of great importance to other communities along the river, and to the counties and the State, and also, because of the benefits to navigation, to the National Government.

16. Reservoirs for flood control have been built in other countries, and have been so successful, both in preventing floods and in improving the low-water flow and navigability of the rivers, that other large works of this kind are now under construction and many more are contemplated.

17. Prevention of Pittsburgh floods by storage reservoirs has in the past been pronounced possible by a number of eminent engineers. It has generally been thought impracticable because of the cost, but these opinions as to cost were not in any case based on actual surveys, designs and estimates.

18. The estimates of the cost of storage reservoirs and other works for flood relief, made by the Flood Commission, are based on detailed surveys, and show that Pittsburgh can be completely safeguarded against floods at the cost of about $20,000,000.

19. The Flood Commission urges the carrying out of the proposed works for flood relief at the earliest possible date. The expenditure of this sum of $20,000,000 is warranted for the following reasons:

(a) Had this expenditure been made, so that the benefits therefrom would have been realized through the past ten years, more than half the amount would have been saved by the prevention of flood damage at Pittsburgh alone.

(b) The cost is but one-half the direct loss, amounting to $40,000,000, that it is estimated will otherwise be caused by flood damage at Pittsburgh in the next twenty years.

(c) The cost is small considering the total loss by flood damage in a few years, in all the districts that would receive benefits from flood relief.

(d) The flood losses along the Ohio Valley in one year, 1907, are stated to have amounted to over $100,000,000. The proposed reservoir system would completely relieve the upper Ohio from damaging floods, and reduce their height and damage for a considerable distance downstream.

(e) The expenditure of the sum necessary upon the Allegheny and Monongahela rivers would be the important beginning of the construction of a comprehensive reservoir system upon all tributaries of the Ohio River. Such an extension of the system would prevent floods throughout the entire Ohio Valley.

(f) The reduction of the maximum and the increase of the minimum flow of those streams that are now navigable for any portion of the year, would greatly increase the traffic opportunities upon them. At the maximum height, the current would be greatly reduced, the clearance under the bridges increased, and access to landings easily obtained. During the lowest stage there would be a sufficient depth of water for vessels of ordinary draft.

(g) The annual saving due to the improved quality of the water for domestic and industrial uses, and the prevention of damage resulting from chemical impurities in the water, at low stages of the streams, would, in itself, warrant an expenditure of a considerable portion of the cost of the proposed flood prevention.

(h) The large area affected by floods in Pittsburgh includes real estate having an assessed valuation of $160,000,000. If relieved from the flood menace, this property would be increased in value at least $50,000,000, or more than twice the cost of the necessary flood relief measures.

(i) The water power that would be developed could be utilized to produce electrical energy, and would yield a revenue that would contribute to the cost of maintaining and operating the reservoir system, as well as rendering a return upon the investment.

A Freight Locomotive was Derailed Oct. 28, on the Trinity & Brazos Valley Ry., near Karen, Tex. Eight box cars were demolished, according to reports, and the engineer, fireman and brakeman were killed. The accident is quaintly explained as follows in the Houston "Post":

The wreck was caused by the crown sheet on the engine becoming detached in some way and dropping to the track, beneath the engine. As the three men killed were the only ones in the neighborhood of the engine when the crown sheet dropped, no details of the cause of its falling are known. When it dropped to the track it immediately derailed the engine, completely overturning it.

A Powder Mill Explosion at the DuPont works in Haskells, N. J., Nov. 1, was followed by a fire which completed the ruin of three buildings with a loss estimated at $60,000. One man was injured.

On the same date, a fire destroyed the powder mill of the Imperial Powder Co., at Chehalis, Wash. Reports state that seven persons were killed.

A Bridge Under Construction Collapsed Nov. 4 eight miles from Auburn, Cal[illegible]ng to reports, carrying down 50 work[illegible]m 16 were killed. The bridge was being built for the Mountain Quarries Co., to carry its private railway line across the American River.

The Greek Steamer "Lordos Byron" sank in the English Channel, Nov. 5, during a storm. Of her crew of 25, all but three were drowned. The vessel was bound for Antwerp from Theodosia.

The Cross Country Flight of [illegible]. Rodgers, between the Atlantic and Pacific coasts was practically completed on Nov. 5, at Pasadena, Cal. The start was made from Sheepsh[illegible] New York City, on Sept. 17 and 50 days [illegible] by the trip, but there were various [illegible] of several days. The total distance is reported as 4,231 miles and the actual flying time, 3 days, 10 hrs., 4 mins., making an average speed in the air of 51.6 mi. per hr. A small Wright biplane flyer was used.

A Mobilization of the U. S. Navy was carried out during the last days of October and first of November. Two fleets were simultaneously assembled on the Atlantic and Pacific Coasts respectively. By far the larger fleet was that brought together at New York City in the Hudson River, comprising a total of 99 vessels, including colliers, transports, repair ships, torpedo boats, cruisers and battleships, of which 24 were first-class battleships. The largest vessels were the "Utah," described in our issue of Nov. 2, and her sister ship, the "Florida," which was towed to her anchorage by tugs from the Brooklyn Navy Yard. The "Florida" was described as practically completed, but had never been operated under her own power. She sailed under her own power, however, on Nov. 3, when the fleet passed in review before President Taft on the yacht "Mayflower," before disbanding.

The Pacific fleet, 24 ships in all, among which the "Oregon" was the only first-class battleship, was reviewed by Admiral Thomas in Los Angeles harbor on the same date.

The Time for Taking Testimony in the Passaic Valley-New York Harbor sewage disposal suit has been extended to March 31, 1912, by the U. S. Supreme Court, on petition of the New York authorities.

Non-oxidizing Copper for electrically-heated soldering irons and similar tools has been developed in the Research Laboratories of the General Electric Co., Schenectady, N. Y. The rapid wasting away of such copper tools has always been objectionable, particularly with the electrically heated irons. It is stated that this "calorized" metal is not given a mere surface coating, but that the change penetrates to a considerable depth. The copper is resistant to oxidation and to corrosion by soldering acids and the dissolving action of the molten tin with which the working tip of a soldering iron must be kept coated.

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Real estate	$12,393,398
Various water-supply systems	7,691,533
City distributing reservoir	649,499
Pumping plants	1,216,207
City pipe system	4,500,000
Meters	150,000
Stock on hand	270,000
Special structures	59,316
Engineering and interest	1,764,569
Total	$28,694,522
Less depreciation	2,922,538
	$25,771, 984

In our issue of Oct. 22, 1908 (p. 459), we published a brief note stating that an interlocutory injunct[illegible] been issued against the 1908-9 rate [illegible] value of the property for rate making purposes had been fixed by the court at $27,550,000; that the court had declared the company entitled to 5% earnings on that amount, over and above operating expenses, taxes and depreciation; and that pending a final decision the company might collect 15% in excess of the 1908-9 ordinance rates, but must pay the excess into the court. Whether the valuation last named was on the same basis as that just fixed by the court does not appear in the information at hand.

The Olive Bridge Dam, which is the largest structure in connection with the formation of the [illegible]an reservoir for the new Catskill [illegible]y for New York City, had the last [illegible] block placed on Thursday, Nov. 2, and the last few batches of concrete on the following day, Nov. 3. The dam has been built under direction of the Board of Water Supply, with MacArthur Bros. Co. and Winston & Co. as contractors. It is claimed that the placing of some 500,000 cu. yds. of masonry in about 25 working months establishes a new record for rapid progress on this class of construction. Mr. M. J. Look, M. Am. Soc. C. E., is General Superintendent for the contractors.

A New System of Gathering Turpentine.—In Engineering News, March 18, 1909, improved methods of bleeding pine trees for turpentine and rosin were described. The improvement noted was the substitution of the "cup-and-gutter" system for the older injurious and uneconomic "boxing." The old method consisted in cutting a cavity in the base of the tree to serve as a cup to catch the sap. As the sap flows out of the sapwood, the latter becomes clogged and the cut has to be extended higher and higher. This cutting decreases the timber value of the tree and renders it more liable to destruction by wind and fire, and also retards growth. The second method consisted of wounding the tree and receiving the sap into a gutter fastened just below the wound and leading to a deep earthenware cup. A third scheme is now being tried, and is described in the "Scientific American," Oct. 28, 1911. The necessary equipment consists of an air-tight glass jar of about one pint capacity, on which is screwed a metallic cover to which is attached a shallow cup extending up at right angles thereto and connecting with the cover by a hollow reinforcing brace. The cup is attached to the tree by first smoothing off the rough outer bark for a few square inches, and then boring into the tree for about ¼-in. with an extension bit so as to provide a shallow hole the size of the vertical cup attached to the cover of the jar. Before forcing the cup into this hole, two ¾-in. diverging holes are bored several inches deep and slightly upward from the center of the large hole. The sap then flows from these ¾-in. holes into the larger hole and into the vertical cap and glass jar. When the jars become full, they can be unscrewed, emptied and replaced without removing the cover from the tree. It is claimed that the method can be continued for an indefinite period without damage to the tree, and that the system does away with all chipping or hacking, protects the tree from fire and does not retard its growth.

Railway Casualties for the year ending June 30, 1911, are reported by the Interstate Commerce Commission in Accident Bulletin No. 40, just issued. This is the first year in which a complete record of railway casualties has been obtained by the Commission under the law of May 6, 1910. The total number of casualties for the year ending June 30, 1911, was 160,555 (10,396 killed and 150,159 injured). Of this number, 439 killed and 79,237 injured are classed under the head of "Industrial Accidents," which do not involve the movement of cars or engines on rails. During the year, a total of 5,284 persons were killed and 5,614 injured while trespassing on the property of the railroad, walking on the tracks or stealing rides on trains.

There was a noticeable decrease in the number of passengers killed during the year, as compared with the previous year, being 356 against 421. Only 142 of the passengers killed lost their lives in train accidents, as compared with 217 in the previous year.

Accident reports on electric lines which carry interstate traffic show that there were 410 persons killed and 3,264 injured during the year, exclusive of "Industrial Accidents."

The total number of employees in the service of the railroad companies on June 30, 1911, was 1,648,033. During the year ending June 30, 1911, there was one employee killed to every 458 employed, and one employee injured to every 13 employed.

Power Brakes on Heavy Street Cars have been ordered by the Public Service Commission for the First District of New York. Proceedings were instituted some time ago to ascertain whether the surface cars operated within the city of New York were equipped with proper brakes, the transportation engineer of the Commission having reported that more accidents had occurred on cars equipped with hand brakes than on those of the same weight with power brakes. It was conceded by witnesses that cars of certain weight should be equipped with power brakes, while cars below that weight could be safely operated by hand brakes. The dividing line recommended by the transportation engineer was at double-truck cars weighing over 25,000 lbs. The Commission, in accordance with the report of Commissioner Eustis, adopted the following order:

ORDERED (1) That after June 1, 1912, all passenger double-truck surface cars in service weighing over 27,000 lbs. shall be equipped with power brakes and geared hand brakes;

(2) That after June 1, 1912, all passenger double-truck surface cars in service weighing over 25,100 lbs. shall be equipped with power brakes and geared hand brakes;

(3) That after June 1, 1912, all other passenger double-truck surface cars in service weighing 25,100 lbs., or less, shall be equipped with geared hand brakes; and

(4) That after June 1, 1912, all surface cars in service, other than passenger cars, shall be equipped with power brakes and geared hand brakes.

An Emergency Water-supply for New York City through the Catskill Aqueduct, now under construction by the Board of Water Supply, may be easily possible before the close of 1912. To effect this the only construction work not already in progress or under contract would be the installation of a pumping plant and short connections to deliver water from Esopus Creek into the upper end of the aqueduct, with a total lift of about 100 ft. The water would then flow by gravity through the aqueduct to a point on the shore of Croton Lake, where it would be discharged into the lake through a permanent blow-off recently contracted for. The possibility outlined depends chiefly upon the early successful completion of the deep pressure tunnel now being driven beneath the Hudson River (see Eng. News, March 23, 1911, for latest article on this work and for references to earlier articles). In Nov. 1, 1911, about half the total length of this tunnel had been holed. Earlier difficulties with water at the easterly heading had been overcome some time before, so that good progress was being made from each heading. Indications were favorable for the meeting of the headings by February, 1912, and for the completion of the lining before the end of 1912.

Personals.

Mr. F. N. Reynolds, formerly Trainmaster at St. Paul, Minn., of the Chicago Great Western Ry., has been promoted to Superintendent of Terminals at Oelwein, Iowa, for the same road.

Mr. F. C. Pickard, Master Mechanic of the Cincinnati, Hamilton & Dayton R. R. at Indianapolis, Ind., has resigned to accept a similar position with the Pere Marguette R. R., at Saginaw, Mich.

Mr. T. S. Lloyd has resigned as Superintendent of Motive Power and Equipment of the Delaware, Lackawanna & Western R. R., effective at the pleasure of the company and the selection of his successor.

Mr. J. F. Deems, General Superintendent of Motive Power, Rolling Stock and Machinery of the New York Central Lines, has resigned to accept the presidency of the Ward Equipment Co., of New York City.

Mr. F. S. Rockwell, Trainmaster of the Chesapeake & Ohio Ry., at St. Albans, W. Va., has been promoted to Superintendent of the Cincinnati division with headquarters at Covington, Ky., succeeding the late T. J. Conners.

Mr. Pierre Hulsart, a civil engineering employee of the Board of Water Supply of the City of New York, fell 30 ft. in an open shaft on the construction work in Bronx Borough, on Nov. 1. He sustained serious injuries, from which, however, it is expected he will recover.

Mr. Bruce W. Benedict, for several years in the Motive Power Department of the Atchison, Topeka & Santa Fe Ry., has been appointed Director of the Shop Laboratories in the Department of Mechanical Engineering at the University of Illinois. Mr. Benedict graduated from the University of Nebraska in 1901. For a number of years he was with the mechanical department of the Chicago, Burlington & Quincy R. R., and for two years editor of the "Railway Master Mechanic."

Mr. I. F. Stern, M. Am. Soc. C. E., Engineer of Bridges of the Chicago & Northwestern Ry., has resigned and will open offices in the Old Colony Bldg., Chicago, Ill., as a consulting civil engineer. Mr. Stern is a native of Chicago and a graduate of the University of Michigan, class of 1895. He has been in the bridge department of the Chicago & Northwestern Ry. since 1901; first serving as a draftsman. In 1905, he was Resident Engineer of the Long Pine Viaduct in Nebraska, and since September of that year has been Bridge Engineer, in charge of the design and erection of all bridge structures, including track elevation work.

Mr. J. P. Coleman, Chief Engineer of the Union Switch & Signal Co., has resigned and has been appointed Consulting Engineer of the same company. Mr. L. F. Howard, M. Am. Inst. E. E., formerly Electrical Engineer, succeeds Mr. Coleman, under the title of Engineering Manager, with full responsibility for the organization and administration of the engineering department of the company. Mr. F. B. Corey, M. Am. Inst. E. E., formerly Engineer with the General Electric Co., at Schenectady, N. Y, has been appointed Engineer in charge of the inspection department, which will be reorganized under his direction.

Mr. Waldemar Lindgren, M. Am. Inst. M. E., for many years a geologist in the U. S. Geological Survey, has been appointed Chief Geologist of the Survey. Mr. Lindgren joined the Geological Survey in 1884. During his connection with the Survey he has also served as Associate Professor in Mining and Metallurgy at Leland Stanford University, California, and as Lecturer on Economic Geology at the Massachusetts Institute of Technology. Since 1907 he has been in charge of the investigations of the Geological Survey of metalliferous deposits, and during the same period has reorganized the metal statistics under the Division of Mineral Resources. Mr. Lindgren is a native of Sweden and received his technical education at the School of Mines at Freiberg, Saxony, where he received his degree in 1883. He is the author of some 50 reports of the Geological Survey and has a wide reputation as an authority on the geology of ore deposits.

Obituary.

Aaron Francis Stowe, an inventor of boot and shoe machinery now controlled by the United Shoe Machinery Co., died at his home in Worcester, Mass., on Oct. 29, aged 78 years.

The Pittsburgh Flood Commission's Report: Storage Reservoirs Recommended.

The Commission organized by the Pittsburgh Chamber of Commerce three years ago, following the severe flood damage experienced by Pittsburgh in 1907-8, to investigate possible methods of protecting the city against floods, has completed its report, which is now in the printer's hands. Through the courtesy of the Commission we are enabled to print herewith the opening chapter of its report in which the results of its investigations are summarized. It will be seen that the Commission recommends unqualifiedly the construction of storage reservoirs on the tributaries of the Allegheny and Monongahela as by far the best method of flood prevention.

In order that due weight may be given to this important recommendation, it should be understood that it is made on the authority of a number of well-known engineers. The officers of the Flood Commission are H. J. Heinz, President; Albert J. Logan, H. D. W. English, Vice-Presidents, George M. Lehman, Gen. Secretary. The engineering committees of the Commission were made up as follows:

Engineering—E. K. Morse, Chairman; Emil Swensson, Vice-Chairman; Geo. S. Davison, Paul Didier, Julian Kennedy, Morris Knowles, George M. Lehman, W. G. Wilkins.

Flood Prevention—W. G. Wilkins, Chairman; Morris Knowles, George M. Lehman, E. K. Morse, Emil Swensson.

Flood Protection—Emil Swensson, Chairman; Paul Didier, Julian Kennedy, George M. Lehman, E. K. Morse.

Sewage Disposal—Morris Knowles, W. G. Wilkins.

George M. Lehman, Engineer in Charge; Kenneth C. Grant, Principal Assistant Engineer.

The chapter of the report entitled "Results of Investigations" follows:

The investigations and surveys of the Flood Commission, and studies based thereon, as fully described in the following chapters of this report, enable the Commission to make the following statements:

1. Floods at Pittsburgh are increasing in frequency and height.

2. There is every possibility that Pittsburgh will some day experience a forty-foot flood.

3. The damage at Pittsburgh resulting from a flood of a given height is steadily increasing.

4. The direct losses due to flood damage at Pittsburgh amounted to over $12,000,000 in the last ten years, while in one year and five days, between March 15, 1907, and March 20, 1908, three floods occurred, causing a direct loss at Pittsburgh of about $6,500,000.

5. If works for flood relief are not carried out, the direct losses due to flood damage at Pittsburgh alone will, on a conservative estimate, amount to $40,000,000 in the next twenty years.

6. The flood losses along the Ohio Valley in one year, 1907, are stated in the preliminary report of the Inland Waterways Commission for 1908 to have amounted to over $100,000,000.

7. Flood relief by some form of local protection only, without storage reservoirs, cannot be recommended because:

(a) Such protective measures would give local relief ony.

(b) Such local relief would be the only benefit derived.

(c) Dredging alone, without reservoirs, would not reduce floods sufficiently, and a wall would still have to be built.

(d) The wall, without reservoirs, would have to be too high and would be too costly.

8. The flood water that would otherwise cause damage can be impounded in storage reservoirs, and by this means floods can be prevented.

9. There are many favorable reservoir sites of large capacity available for flood water storage on the drainage areas bove Pittsburgh.

10. Forty-three sites have been selected and most of them completely surveyed by the Flood Commission, the others having been studied from existing topographical maps and by means of partial surveys.

11. From a study of the relative effectiveness of the various projects it was determined that adequate flood reduction at Pittsburgh could be obtained with 28 of these reservoirs, while a final analysis reduced the number to 17.

12. If the Seventeen Selected Projects above referred to had been in operation, without any wall, the storage of flood water in these reservoirs would have reduced all past Pittsburgh floods to below the danger mark, or 22-foot stage, with the exception of the great flood of March, 1907, which would have been reduced from a stage of 35.5 ft. to a stage of 27.6 ft.

13. Supplementing the Seventeen Selected Projects by a wall along the low-lying portions of the river bank would confine all floods, including a possible forty-foot flood, within the river channels.

14. Flood prevention by storage reservoirs is possible and practicable, and is recommended because:

(a) The flood relief would be extended over hundreds of miles of tributaries and of the main rivers, including the Ohio for many miles below Pittsburgh.

(b) The impounded flood water, with proper manipulation of the reservoir system, would considerably increase the low-water flow of the tributaries and of the main rivers.

(c) This increased low-water flow would greatly aid navigation and interstate commerce.

(d) The increased low-water flow would notably improve the quality of the water for domestic and industrial purposes.

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(b) The cost is but one-half the direct loss, amounting to $40,000,000, that it is estimated will otherwise be caused by flood damage at Pittsburgh in the next twenty years.

(c) The cost is small considering the total loss by flood damage in a few years, in all the districts that would receive benefits from flood relief.

(d) The flood losses along the Ohio Valley in one year, 1907, are stated to have amounted to over $100,000,000. The proposed reservoir system would completely relieve the upper Ohio from damaging floods, and reduce their height and damage for a considerable distance downstream.

(e) The expenditure of the sum necessary upon the Allegheny and Monongahela rivers would be the important beginning of the construction of a comprehensive reservoir system upon all tributaries of the Ohio River. Such an extension of the system would prevent floods throughout the entire Ohio Valley.

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(3) That after June 1, 1912, all other passenger double-truck surface cars in service weighing 25,100 lbs., or less, shall be equipped with geared hand brakes; and

(4) That after June 1, 1912, all surface cars in service, other than passenger cars, shall be equipped with power brakes and geared hand brakes.

An Emergency Water-supply for New York City through the Catskill Aqueduct, now under construction by the Board of Water Supply, may be easily possible before the close of 1912. To effect this the only construction work not already in progress or under contract would be the installation of a pumping plant and short connections to deliver water from Esopus Creek into the upper end of the aqueduct, with a total lift of about 100 ft. The water would then flow by gravity through the aqueduct to a point on the shore of Croton Lake, where it would be discharged into the lake through a permanent blow-off recently contracted for. The possibility outlined depends chiefly upon the early successful completion of the deep pressure tunnel now being driven beneath the Hudson River (see Eng. News, March 23, 1911, for latest article on this work and for references to earlier articles). In Nov. 1, 1911, about half the total length of this tunnel had been holed. Earlier difficulties with water at the easterly heading had been overcome some time before, so that good progress was being made from each heading. Indications were favorable for the meeting of the headings by February, 1912, and for the completion of the lining before the end of 1912.

Personals.

Mr. F. N. Reynolds, formerly Trainmaster at St. Paul, Minn., of the Chicago Great Western Ry., has been promoted to Superintendent of Terminals at Oelwein, Iowa, for the same road.

Mr. F. C. Pickard, Master Mechanic of the Cincinnati, Hamilton & Dayton R. R. at Indianapolis, Ind., has resigned to accept a similar position with the Pere Marguette R. R., at Saginaw, Mich.

Mr. T. S. Lloyd has resigned as Superintendent of Motive Power and Equipment of the Delaware, Lackawanna & Western R. R., effective at the pleasure of the company and the selection of his successor.

Mr. J. F. Deems, General Superintendent of Motive Power, Rolling Stock and Machinery of the New York Central Lines, has resigned to accept the presidency of the Ward Equipment Co., of New York City.

Mr. F. S. Rockwell, Trainmaster of the Chesapeake & Ohio Ry., at St. Albans, W. Va., has been promoted to Superintendent of the Cincinnati division with headquarters at Covington, Ky., succeeding the late T. J. Conners.

Mr. Pierre Hulsart, a civil engineering employee of the Board of Water Supply of the City of New York, fell 30 ft. in an open shaft on the construction work in Bronx Borough, on Nov. 1. He sustained serious injuries, from which, however, it is expected he will recover.

Mr. Bruce W. Benedict, for several years in the Motive Power Department of the Atchison, Topeka & Santa Fe Ry., has been appointed Director of the Shop Laboratories in the Department of Mechanical Engineering at the University of Illinois. Mr. Benedict graduated from the University of Nebraska in 1901. For a number of years he was with the mechanical department of the Chicago, Burlington & Quincy R. R., and for two years editor of the "Railway Master Mechanic."

Mr. I. F. Stern, M. Am. Soc. C. E., Engineer of Bridges of the Chicago & Northwestern Ry., has resigned and will open offices in the Old Colony Bldg., Chicago, Ill., as a consulting civil engineer. Mr. Stern is a native of Chicago and a graduate of the University of Michigan, class of 1895. He has been in the bridge department of the Chicago & Northwestern Ry. since 1901; first serving as a draftsman. In 1905, he was Resident Engineer of the Long Pine Viaduct in Nebraska, and since September of that year has been Bridge Engineer, in charge of the design and erection of all bridge structures, including track elevation work.

Mr. J. P. Coleman, Chief Engineer of the Union Switch & Signal Co., has resigned and has been appointed Consulting Engineer of the same company. Mr. L. F. Howard, M. Am. Inst. E. E., formerly Electrical Engineer, succeeds Mr. Coleman, under the title of Engineering Manager, with full responsibility for the organization and administration of the engineering department of the company. Mr. F. B. Corey, M. Am. Inst. E. E., formerly Engineer with the General Electric Co., at Schenectady, N. Y, has been appointed Engineer in charge of the inspection department, which will be reorganized under his direction.

Mr. Waldemar Lindgren, M. Am. Inst. M. E., for many years a geologist in the U. S. Geological Survey, has been appointed Chief Geologist of the Survey. Mr. Lindgren joined the Geological Survey in 1884. During his connection with the Survey he has also served as Associate Professor in Mining and Metallurgy at Leland Stanford University, California, and as Lecturer on Economic Geology at the Massachusetts Institute of Technology. Since 1907 he has been in charge of the investigations of the Geological Survey of metalliferous deposits, and during the same period has reorganized the metal statistics under the Division of Mineral Resources. Mr. Lindgren is a native of Sweden and received his technical education at the School of Mines at Freiberg, Saxony, where he received his degree in 1883. He is the author of some 50 reports of the Geological Survey and has a wide reputation as an authority on the geology of ore deposits.

Obituary.

Aaron Francis Stowe, an inventor of boot and shoe machinery now controlled by the United Shoe Machinery Co., died at his home in Worcester, Mass., on Oct. 29, aged 78 years.

George William Jones, Professor of Mathematics, at Cornell University for 31 years, died on Oct. 30, at his home in Ithaca, N. Y. He was born in East Corinth, Me., and graduated from Yale University in 1859. He had been connected with Cornell University since 1874. He was retired as head of the department of mathematics in 1907.

John A. Roche, a pioneer builder of steam engines, of Springfield, Mass., died on Oct. 30, aged 78 years. He was born in Ireland and came to this country in 1849. Under the name of Roche Bros., he and his brother engaged in the manufacture of engines and machinery in 1861. He built the engines and machinery for the first Connecticut River steamboat to ply between Springfield and Holyoke. The business was discontinued in 1873.

Norman J. Coleman, the first Secretary of the U. S. Department of Agriculture, died on Nov. 3, on a railway train en route to St. Louis, Mo., where his home was. He was chiefly noted as a lawyer, although always interested in agriculture and at one time owner of an agricultural newspaper. He was United States Commissioner of Agriculture from 1885-1889, and was appointed Secretary of the Department of Agriculture when that cabinet position was created in February, 1889. He was 84 years old.

Henry W. Bulkley, M. Am. Soc. M. E., died at his home in East Orange, N. J., on Nov. 6. He was born in New York City, on July 22, 1841, and was educated at the college of the City of New York. During the Civil War he served in the engineering department of the U. S. Navy. He was the inventor and manufacturer of the "Bulkley" air pumps, condensers, injectors and other mechanical devices. Mr. Bulkley was also a member of the American Institute of Mining Engineers.

James Benton Grant, M. Am. Inst. M. E., died at Excelsior Springs, Mo., on Nov. 1. He was born in Russell Co., Ala., Jan. 2, 1848. He served in the Confederate Army for a year during the Civil War. After the War he went to Iowa and graduated from the Iowa Agricultural College. He continued his education at Cornell University and the School of Mines at Freiburg in Germany. Returning to this country he settled in Denver, Colo., in 1876, and became actively interested in mining enterprises, and soon made a fortune. He was Governor of Colorado from 1883 to 1885. At the time of his death he was a member of the executive committee of the American Smelting & Refining Co.

Daniel F. Drawbaugh, the leading figure in one of the famous lawsuits carried on against Alexander Graham Bell, inventor of the telephone, during the early days of the Bell Telephone Co., died on Nov. 3, at his home in Harrisburg, Pa., at the age of 84 years. Mr. Drawbaugh was a mechanic in a small village near Harrisburg when he first came into prominence as the pretended inventor of the telephone. His claim was that he had invented a complete telephone and switchboard prior to 1876, but was in such a poverty-stricken condition that he could not afford to take out a patent. Five hundred witnesses were examined and the case was long and expensive. The decision was given in favor of the Bell Telephone Co. Soon after this case was decided, the whole dispute with Drawbaugh and other claimants was reopened and was not finally settled until 1896. Mr. Drawbaugh came forward again in 1903 as a claimant for the invention of the wireless telegraph. His ruling passion seems to have been the imitating of other person's inventions. More than 40 such instances of his claims were shown at the time of the telephone patent trial.

Engineering Societies.

COMING MEETINGS.

NATIONAL MUNICIPAL LEAGUE.
Nov. 13-16. Annual meeting at Richmond, Va. Secy., Clinton R. Woodruff, 705 North American Bldg., Philadelphia, Pa.

AMERICAN ROAD BUILDERS' ASSOCIATION.
Nov. 14-17. Annual convention at Rochester, N. Y. Secy., E. L. Powers, 150 Nassau St., New York City.

AMERICAN RAILWAY ASSOCIATION.
Nov. 15. Semi-annual meeting at Chicago, Ill. Secy., W. F. Allen, 75 Church St., New York City.

NATIONAL FOUNDERS' ASSOCIATION.
Nov. 15-16. Annual convention at New York City. Secy., F. W. Hutchings, 915 Hammond Bldg., Detroit, Mich.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 16-17. Annual meeting at New York City. Acting Secy., D. H. Cox, 29 West 39th St., New York City.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS.
Nov. 17-18. Annual meeting at Canton, Ohio. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

ENGINEERING ASSOCIATION OF THE SOUTH.
Nov. 17-18. Annual meeting at Atlanta, Ga. Secy., H. H. Trabue, Carnegie Library, Nashville, Tenn.

NEW JERSEY SANITARY ASSOCIATION.
Nov. 24-25. Annual meeting at Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 4. Annual meeting at New York City. Secy., William H. Ross, 154 Nassau St., New York City.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Dec. 4-9. Annual meeting at Havana, Cuba. Secy., Wm. C. Woodward, Washington, D. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 5-8. Annual convention at New York City. Secy., Calvin W. Rice, 29 West 39th St., New York City.

NATIONAL IRRIGATION CONGRESS.
Dec. 5-9. Annual session at Chicago, Ill. Secy., Arthur Hooker, 214 Hotel La Salle, Chicago, Ill.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 11-13. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 12-14. Annual convention at Washington, D. C. Secy., Glenn Brown, the Octagon, Washington, D. C.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 20-22. Annual meeting at Washington, D. C. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 27-29. Annual meeting at St. Paul, Minn. Secy., J. B. Davidson, Ames, Iowa.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27-Jan. 3. Annual meeting at Washington, D. C. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.
Jan. 6. Annual meeting at Seattle, Wash. Secy., Joseph Jacobs, 803 Central Bldg., Seattle, Wash.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS.
Jan. 9. Annual meeting at New York City. Secy., J. R. Wemlinger, 13 Park Row, New York City.

American Society for Testing Materials.

The executive committee has announced the election of Mr. A. A. Stevenson to fill the vacancy caused by the death of Mr. James Christie.

American Society of Heating and Ventilating Engineers.

The annual meeting will be held at the Engineering Societies Bldg., in New York City, probably on Jan. 24-25, although the date has not yet been definitely decided.

Canadian Society of Civil Engineers.

At the monthly meeting to be held at Montreal Nov. 9, Mr. F. H. Williams, Electrical Engineer of the Illinois Traction System will present a paper entitled, "The Illinois Traction System."

Master Boiler Makers' Association.

The sixth annual convention will be held in the Fort Pitt Hotel, at Pittsburgh, Pa., May 14-17. This was decided at a meeting of the executive committee held at Pittsburgh, Oct. 28. Mr. Geo. N. Riley, of the National Tube Co., was made chairman of the general committee of arrangements and Mr. J. Rogers Flannery, of the Flannery Bolt Co., was made secretary and treasurer of this committee.

American Institute of Mining Engineers.

At a session of the New York section, held at the Engineering Societies Bldg., Nov. 3, illustrated addresses on "Safety Devices and Appliances in Mines and Metallurgical Works," were presented by Dr. F. L. Hoffman, Statistician of the Prudential Insurance Co. of Newark, N. J., and Dr. Wm. H. Tolman, Director of the American Museum of Safety. The secretary of the New York section is Mr. Bradley Stoughton, 29 West 39th St., New York City.

Maine Society of Civil Engineers.

A party of 40 members made a visit of inspection Nov. 3, to the new hydro-electric plant of the Consolidated Electric Light Co., of Portland, at Bonney Eagle Falls, in the town of Hollis, Me. The trip was made by automobiles from Portland and a number of other plants were visited during the tour. A banquet at Portland in the evening completed the day. Time was found for a short business meeting, at which five new members were admitted, making the total membership now 128.

American Society of Mechanical Engineers.

The general subject of autogenous and electric welding will be discussed at a meeting to be held at the Engineering Societies Bldg., New York City, Nov. 14. Three papers will be presented: "Thermit Welding," by G. E. Pellissier, of the Goldschmidt Thermit Co.; "Electric Welding," by C. B. Auel, of the Westinghouse Electric & Manufacturing Co., and a third paper by Mr. H. R. Cobleigh, of the International Steam Pump Co., on the general aspects of the subject, origin and principles of each process and the apparatus used in each. In addition to the processes named, oxy-acetylene and oxy-hydrogen welding will be included in the discussion.

Engineers' Club of Baltimore.

The publication of a monthly "Journal" has been undertaken by this club. The first issue (paper; 8½ × 11 ins.; pp. 14; no illustrations) is dated November, 1911. In addition to club notes and personal items it contains articles on "The Public Service Commission of Maryland," by Charles E. Phelps, and on "Baltimore as an Industrial City; and the Factory Site Commission," by A. S. Goldsborough; editorials on "The Journal" and "The Engineers' Club," and a complete reprint of the club's proposed charter and amended by-laws. The editors are Oscar F. Lackey, John H. Milburn and John K. Flick; associates, Charles E. Phelps, Jr., and Charles E. Sudler. The subscription price is one dollar per year.

Gas, Electric and Electric Railway Association of Oklahoma.

An organization under this name was effected at Oklahoma City, Oct. 6, 1911. Officers were elected as follows: President, Noel R. Gascho, Manager of the Alva Light & Power Co.; Vice-President, Fred Caldwell, Manager of the Shawnee Gas & Electric Co.; Secretary-Treasurer, Prof. Harold V. Bozell, Director of the School of Electrical Engineering, University of Oklahoma, Okla.; Directors, Galen Crow, Guthrie; Mr. Galloway, Tulsa; V. H. Francis, Kingfisher, and L. A. Pritchett, Marlow.

The constitution provides for three classes of members. The first, Class A, is open to managers and directors of gas, electric or railway companies; the second, to other employees of such companies, and the third to any one interested in the gas, electric or railway business or skilled therein. Only the Class A members, however, may hold office and vote.

Following the election of officers, President Gascho gave an address on the subject of "co-operation, not combination," in which he outlined the purposes of the Association as follows:

It seems to me that our greatest field of endeavor at this time would be in cooperating with the Corporation Commission. We should not only cooperate as an organization, but as member companies and individuals and lend it every assistance possible to get it in possession of facts as to conditions as they actually exist in connection with our business. It is through the Commission that the Public Utility companies have their best avenue of reaching the public.

The Commission is as much the Commission of the Public Utilities as it is of the public. So long as men of high standing and with honesty of purpose are elected to these important positions neither the public, nor the Public Utility companies have anything to fear.

By proper cooperation with the Commission I believe that municipalities engaged in furnishing light and power to their inhabitants could be required to keep their accounts, and make reports in detail to the commission as to income, expenses and earnings the same as we who are engaged in a like business. In place of this being a hardship upon the municipalities it would be a most excellent thing for them. We all know of plants operated by municipalities which are not paying ordinary operating expenses, to say nothing of keeping up interest on bonds, and depreciation. Yet these same municipalities have much lower rates than other towns furnishing a like service. We propose that this state of affairs be gone into by the Commission and the municipalities be shown where they are operating at a loss, and the rates brought up where they belong so as to pay expenses, interest on the bonds, provide for depreciation, etc.

In some of the states the public utilities looked upon the coming of state regulation with fear and trembling, thinking that dividends would be wiped out and property ruined. In the states where regulation is in the lead they have found that it is as much benefit to the utility companies as it is to the public, and in fact it has proven to be the missing link in the chain of confidence between the company and the customers.

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